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DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT—INDEPENDENT AGENCIES APPROPRIATIONS FOR 1980

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HEARINGS

BEFORE A

SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS HOUSE OF REPRESENTATIVES

NINETY-SIXTH CONGRESS

FIRST SESSION

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PART 4

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Printed for the use of the Committee on Appropriations

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DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT—INDEPENDENT AGENCIES APPROPRIATIONS FOR FISCAL YEAR 1980

TUESDAY, MARCH 6, 1979.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WITNESSES

DR. ROBERT A. FROSCH, ADMINISTRATOR
DR. ALAN M. LOVELACE, DEPUTY ADMINISTRATOR
ROBERT F. ALLNUTT, ASSOCIATE DEPUTY ADMINISTRATOR
WILLIAM E. LILLY, COMPTROLLER
GEN. BILLIE McGARVEY, DIRECTOR OF FACILITIES
S. NEIL HOSENBALL, GENERAL COUNSEL
ARNOLD W. FRUTKIN, ASSOCIATE ADMINISTRATOR FOR EXTERNAL RELATIONS
JOHN F. YARDLEY, ASSOCIATE ADMINISTRATOR FOR SPACE TRANSPORTATION SYSTEMS
RAY KLINE, ASSOCIATE ADMINISTRATOR FOR MANAGEMENT OPERATIONS
DR. JAMES KRAMER, ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY
DR. NOEL W. HINNERS, ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE
DR. ANTHONY J. CALIO, ASSOCIATE ADMINISTRATOR FOR SPACE AND TERRESTRIAL APPLICATIONS
DR. WILLIAM SCHNEIDER, ASSOCIATE ADMINISTRATOR FOR SPACE TRACKING AND DATA SYSTEMS
DR. HARRIETT G. JENKINS, DIRECTOR OF EQUAL OPPORTUNITY PROGRAMS

	Fiscal year—		
	1978	1979	1980
Appropriation:			
Research and development	$3,011,600,000	[1] $3,477,200,000	$3,602,500,000
Construction of facilities	162,340,000	147,500,000	157,600,000
Research and program management	889,506,000	[2] 941,469,000	964,900,000
Total	4,063,446,000	4,566,169,000	4,725,000,000
Positions	23,237	22,831	22,563

[1] Assumes enactment of proposed supplemental of $185,000,000 for the Space shuttle.
[2] Includes proposed supplemental of $30,969,000 to cover October 1978 paycosts.

Mr. BOLAND. The Committee will come to order. We are delighted to have with us today witnesses for the National Aeronautics and Space Administration. We open our HUD-Independent Agencies 1980 hearings with NASA, which was established on October 1, 1958, and charged with the mission of conducting peaceful space and aeronautics activities and with maintaining United States leadership in aeronautical and space research.

For 1980, NASA is requesting $4,725,000,000. This is an increase of $158,831,000 above 1979 when the proposed supplemental of $185,000,000 for the Space Shuttle, and $30,969,000 for pay costs is assumed to be enacted.

The 1980 level of funding reflects a very modest increase of only 3.5 percent, with no proposed new starts.

I suspect the past year could be characterized as difficult and probably frustrating at times. You have experienced a major spacecraft failure with the early demise of SEASAT; the Tracking and Data Relay Satellite System has incurred a $75,000,000 cost overrun; the Skylab Rescue Mission was cancelled; and, of course, you had to slip the Shuttle's first manned orbital flight.

The new space policy enunciated by President Carter has been severely criticized as lacking any firm national space goal. Finally, if one looks at NASA's appropriation in 1972, which totaled $3.3 billion and then looks at the 1980 request, which totals $4.7 billion, NASA comes up one billion dollars short in keeping up with inflation. In other words, the $4.7 billion in 1980 buys about 40 percent less than $3.3 billion did in 1972, is that correct Bill?

Mr. LILLY. That is correct.

Mr. BOLAND. We must ask a very important question: What is NASA's problem? It can't be morale because every time there is a fall-off in morale, something exciting happens and everything gets back on track again, and everyone is proud of NASA. So it must be lack of money.

Why can't NASA capture more of the President's budget? Is there enough funding provided for in the President's budget to implement the space policy that the Administration has put forward?

What is your response, Dr. Frosch? Does NASA need more money?

Dr. FROSCH. There are certainly some efforts in NASA that we would like to enhance and to start. We discussed them with OMB in the course of preparing the fiscal year 1980 budget, but they did not get into the budget because of the inflationary and economic pressures on the overall Federal budget.

There are certainly items that were in the original submission to OMB that we would like to do, and we will probably recommend them again in our submission for next year's budget.

Mr. BOLAND. So, money is not a problem for NASA then?

Dr. FROSCH. Money and lack of new starts, I think, are a problem.

Mr. BOLAND. If I recall correctly, this is probably the first budget that I have seen from NASA that hasn't had any new flight starts. Is that a good position?

Dr. FROSCH. This budget is, I think, the first one in a few years that has not had a major flight start.

Mr. BOLAND. Do you really need any major new starts? You know, you have one program going now that is quite a program—the Space Shuttle.

Dr. FROSCH. Yes, and we have other ongoing projects. The Shuttle is currently our top priority.

Mr. BOLAND. You had the $20 billion Apollo program—plus the Shuttle-Space Transportation System is going to cost $15.5 billion. So you do come up with some very significant programs and carry them through. You really don't need any new starts this year, do you?

Dr. FROSCH. I think that we can do alright missing major flight starts this year. I think if we were not to have any for more than a year, at this point, we would begin to have some difficulty in keeping the momentum of the programs going in a logical way.

Mr. BOLAND. Without the new starts, if additional funds were put into this budget, would you use them for the Shuttle? Do you need more money for the Shuttle?

Dr. FROSCH. We certainly need the supplemental.

Mr. BOLAND. You need the supplemental?

Dr. FROSCH. Yes. we need the FY 1979 Shuttle supplemental. We believe that, with the supplemental and with the FY 1980 budget, we can carry forward the program as proposed. Since the time of the budget decision, of course, there have been some other Shuttle engineering problems that were not anticipated in the FY 1980 budget. So we could conceivably use more funding flexibility for the Shuttle, but it is not really required to hold the current program plan as we have described it.

Mr. BOLAND. Let me ask you just one more question before you deliver your general statement. This concerns Dr. Frank Press, who is the scientific advisor to the President, and I quote him:

> American technological capability is admired throughout the world, and it is the foundation for our ability to compete effectively in the international markets. If we wish to maintain our traditional role as a world economic power, we must assure that we maintain the technological edge on our competitors. The President's economic and inflation advisors believe very strongly that over the long term, R&D and technological innovation, will become our most potent weapons in fighting ourselves out of the economic bind in which we currently find ourselves.

Would you agree with that statement?

Dr. FROSCH. I would agree.

Mr. BOLAND. Which brings us back to my question of why NASA comes off so poorly when Dr. Press and the President divide up the dollars.

Dr. FROSCH. I think this year the major problem focused on holding the overall budget down as part of the near-term anti-inflationary program. This budget was the best reasonable compromise, I think, that could be made with that in mind.

As you know, not everything in the budget is easily controllable, or controllable at all. It was felt that we could, in fact, have a year in which we missed major flight starts, and still keep the important momentum in the program. If you look at the structure of the program, a key part is the fact that even though we are at the peak development time in the Space Transportation System, we are beginning to come down from those peak years as we enter 1980, and that decrease makes it possible for there to be increases in some of the other program areas. These increases are required to keep the momentum of the ongoing program, even though they don't provide new flight starts.

Mr. BOLAND. You have touched upon an important concept when you said that some things in the budget are controllable and some are not controllable. This, however, happens to be controllable.

Why don't you go ahead with your statement?

Dr. FROSCH. Mr. Chairman, with your permission, the way I would like to proceed is to offer the entire statement for the record.

[The statement follows:]

General Statement

Dr. Robert A. Frosch
Administrator

before the

Subcommittee on HUD-Independent Agencies
Committee on Appropriations
House of Representatives

Mr. Chairman and Members of the Subcommittee:

It is a pleasure for me to present today the President's request for appropriations for Fiscal Year 1980 for the activities of the National Aeronautics and Space Administration. We are requesting a total of $4.725 billion for FY 1980. Additionally, we are requesting a supplemental appropriation of $185 million for Space Shuttle Design, Development, Test and Evaluation for Fiscal Year 1979 which I will also discuss in this statement. Summary budget charts are attached hereto. Accompanying me today are Dr. Alan M. Lovelace, the NASA Deputy Administrator; Mr. William E. Lilly, the NASA Comptroller; and the senior NASA officials responsible for each of our major activities.

In October of last year in a speech at the Kennedy Space Center, the President outlined his space policy for the coming decade. The policy enunciates a vigorous civilian space program centered on the proposition that the United States will retain scientific and technological world leadership in space activities. The policy, as well as the budget request we bring before you today, emphasizes the Administration's commitment to the completion of the Space Transportation System (STS) followed by exploitation of the flexibility and unique opportunities this system will provide through routine, economical access to earth orbit.

In Space Science, building on the base established through prior appropriations, the policy calls for continued exploration of the planets, exploring the far reaches of the universe, and examining in depth the effects of the sun on the earth's environment. In Space Applications, the policy supports continued activity in the acquisition of data by

remote sensing including efforts toward an operational remote sensing system and work on a new agriculture inventory initiative. We will also renew our research and development efforts in selected areas of communications technology.

Inflation continues as the country's most pressing problem, and the President's total budget, designed to reduce the Federal deficit to less than $30 billion, is tight and austere. In this context, the NASA budget for Fiscal Year 1980 of $4.725 billion and the Fiscal Year 1979 supplemental request of $185 million for the Space Shuttle represent, I believe, a strong Administration commitment to civil space and aeronautics programs. This budget includes no new major flight project starts. However, the multiyear budget projection process has established future fiscal year targets for NASA which offer some flexibility in the selection of new efforts over the next several years.

From an overall standpoint, excluding the supplemental request for the Space Shuttle, the budget total represents an increase over Fiscal Year 1979 of 7.8 percent, which is about equal to inflation. When the Fiscal Year 1979 supplemental amounts requested for the Space Shuttle and Civil Service pay increases are taken into account, the total increase is about 3.5 percent.

I would like to now turn to the major program areas, outlining the highlights of our plans for Fiscal Year 1980.

Space Transportation Systems

The past calendar year was one of significant progress in testing, training and construction in the Space Shuttle program. A major milestone will be reached this weekend when the first orbital vehicle, Columbia (OV-102), will be shipped from the contractor's plant in Palmdale, California, to the Kennedy Space Center in Florida.

Before reviewing our plans in the coming Fiscal Year for the Space Transportation Systems, I would like briefly to summarize the additional requirements in FY 1979 which have necessitated our request for supplemental funding in the amount of $185 million. At the outset, I wish to emphasize that this additional funding is an absolute necessity to continue the Space Shuttle program at a pace which will minimize both total Shuttle development as well as orbiter production costs and will result in the earliest possible transition to the Space Transportation System with the significant flexibility and cost savings it represents to all users.

We have estimated that failure to receive this supplemental funding in FY 1979 would increase total Shuttle program costs by $400 to $600 million. Additional costs would arise to Shuttle payload users due to changes in mission planning if the current schedule is not supported by adequate funding. The purchase of additional expendable launch vehicles would be required for early missions now planned for Shuttle launches. Another major area of impact, more difficult to define, would involve the loss of payload benefits due to optimization for Space Transportation System (STS) launches. Shuttle optimized payloads would have to be redesigned for compatibility with both expendable and STS launches, resulting in cost penalties and postponing the benefits of the expanded capabilities inherent in the STS. As a result, the overall impact of failure to receive the requested supplemental is estimated to be in excess of $1 billion.

The need for additional appropriations in FY 1979 arises from deferred work and additional engineering and manufacturing effort over all elements of the Shuttle program. A large increase in the number of secondary structure parts and certain necessary system changes in the first orbital flight vehicle, Columbia, both contributed to making the final assembly and checkout more complex, time consuming, and costly. For example, changes were required in the hydraulics system, several large helium bottles were added to increase the purge for the main engine seals, and a back-up flight control system was also added. In addition, technical problems, which have since been resolved, were encountered in the reaction control thrusters, the auxiliary power system, and the main propulsion system plumbing.

In the production of thermal protection system (TPS) tiles for the orbiter, new processes had to be developed to produce dimensionally correct tiles. Installation of these tiles, of which there are over 32,000 per orbiter, has taken more time than originally anticipated, as they must be installed in an essentially sequential pattern. Because of a high rejection rate of individual tiles, TPS installation became inefficient as operations were often delayed due to non-availability of specific tiles. While the problem of the sequence of manufacturing has been largely solved, substantial deferral of TPS installation activity to the Kennedy Space Center will be required.

There have also been subcontractor increases in some areas such as the KU-band radar, the environmental control system and the structural test program.

During FY 1978 and early FY 1979, the main engine deliveries for Columbia have slipped seven months. This was principally due to engine test failures and fires with severe damage to three engines: Engine 2001, as a result of a main liquid oxygen (LOX) valve failure; Engine 0007, as a result of a heat exchanger coil failure; and Engine 0006, as a result of a faulty valve and the failure of a repair in the high-pressure fuel turbopump.

As a result of these difficulties, we have retargeted the date for the first manned orbital flight (STS-1) to this November 9. While this date represents a tight "all-success" target schedule, we believe there is a good probability of accomplishing STS-1 before the end of this calendar year.

Our FY 1980 budget request and FY 1979 Shuttle plan are predicated on the availability of the requested supplemental funding. If this additional funding is not forthcoming, a major program restructuring will be necessary, incurring a delay of four to six months in the first orbital flight, a six to twelve month delay in delivery of the second, third and fourth orbiter vehicles, and total cost penalties in excess of $1 billion as discussed above.

Turning now to our plans for the balance of this year, much remains to be done prior to the first manned orbital flight. We are now in the process of completing the full-scale, mated ground vibration tests employing the orbiter Enterprise, combined with an external tank and twin solid rocket boosters, at the Marshall Space Flight Center in Huntsville, Alabama. Significant long-duration runs of the Space Shuttle main engine must be accomplished at the National Space Technology Laboratories in Mississippi, as must a series of full duration flight runs of the three engine configuration main propulsion test article. Three additional solid rocket motor firings are scheduled at the contractor's plant in Utah, and additional thermal protection tiles must be installed on the first orbital flight vehicle, Columbia, after its arrival at the Kennedy Space Center in Florida. All other hardware deliveries have now been phased to support the November 9 target launch date.

In Fiscal Year 1980, we are requesting a total of $610.5 million for Shuttle Design, Development, Test and Evaluation. A significant portion of this funding will be directed toward the four orbital flight tests presently planned for that Fiscal Year. The first flight will be configured to maximize crew and vehicle safety and successive flights will extend the envelope and complexity of operations. Present plans call for an earth-viewing space applications

pallet mission on the second flight, a test of the remote manipulator system on the third, and the launch of a Geostationary Operational Environmental Satellite (GOES) on the fourth test flight.

We are also requesting a total of $755.5 million for continued fabrication and assembly leading to an operational fleet of four orbiters, which were formally named last month: Columbia (orbiter 102), Challenger (orbiter 099, presently the structural test article), Discovery (orbiter 102), and Atlantis (orbiter 104). Funds appropriated in FY 1979 to preserve an option for a fifth orbiter will be applied to long-lead items common to either a four or five orbiter fleet.

In Space Flight Operations, the total request of $467.3 million includes funding for flight hardware for the early STS operational flights now scheduled to begin in February 1981. We have essentially filled the Shuttle manifest for the first two years of STS operations. A visual display of this manifest is attached to my statement. Funds are also included for continued incremental procurement of a second set of Spacelab hardware from the European Space Agency, NASA-unique requirements for the DOD's Inertial Upper Stage (IUS), and hardware procurements of the Spinning Solid Upper Stage (SSUS), currently under private development. We are also requesting $15 million for analysis and initial design of a thrust augmentation option for the Shuttle to increase its payload capability.

Advanced Programs, for which we are requesting a total of $13 million, will focus on mission options to enhance the unique capabilities of the Shuttle. We will investigate advanced power systems, including the completion of definition studies and evaluation of the 25 KW power systems, techniques for construction of space structures, solar electric propulsion, and orbital transfer vehicles.

Mr. Chairman, as you know, NASA decided last December to discontinue the Skylab Reboost/Deorbit project since the reboosting of Skylab was no longer considered a viable option and the deboost option had a very small probability of success. Several factors led to these conclusions. These included the Skylab's orbital decay, higher than expected solar activity, and indications that a TRS mission on the Space Shuttle would be difficult to achieve prior to April 1980. This would have required the Skylab system to continue operating for an additional 16 to 17 months. We did not have the confidence that this could be achieved.

The contract for development of the Teleoperator Retrieval System, which was to be used to reboost or deorbit the Skylab, was terminated on December 18, 1978. After

closeout of the subsystem contracts, any residual FY 1979 funding will be used to support Shuttle activities in accordance with the language of the FY 1979 Appropriations Conference Committee Report. A small study effort has been continued to identify what hardware and TRS design will be utilized for future development of a "generic" TRS.

A Skylab reentry contingency plan has been developed and was forwarded to the White House on February 1, 1979. This plan recommends that NASA chair an interagency working group to coordinate actions to be taken before, during, and after Skylab reentry. In addition, analysis is underway to examine the potential for adjusting Skylab's impact point during the final stages of orbital decay, even though the probability of personal injury or property damage is very low.

Our request of $70.7 million for expendable launch vehicles is earmarked for the Scout, Centaur, Delta and Atlas-F vehicles as we transition to the STS.

Space Science

A total of $601.6 million is requested for Fiscal Year 1980 Space Science R&D programs. No major new flight programs are included. This request provides the necessary support for the continued development of the Space Telescope, the Galileo mission, the International Solar Polar Mission and experiments to be conducted on Spacelab missions. It will also continue operations of current missions including Voyager, Pioneer Venus, the High Energy Astronomical Observatory, International Ultraviolet Explorer, and International Sun-Earth Explorers, as well as the Solar Maximum Mission, to be launched this October.

A total of $112.7 million is requested for continued development of the Space Telescope. Currently scheduled for a Shuttle launch in 1983, this unique instrument will form the centerpiece of our astronomy program for the remainder of the 1980s and beyond. It is being designed for in-orbit maintenance and repair by the Shuttle, and will be recoverable, as well, for refurbishment if necessary.

This budget also provides for the refinement of plans and requirements for the operational era of the Space Telescope. We have concluded that the best approach to maximize scientific return from the program will involve the establishment of a Space Telescope Science Institute

operated under a long-term contract with NASA. We currently plan to release a Request for Proposals early in Fiscal Year 1980 for the operation of the institute.

The major focus of our near-term planetary program will be the "Galileo" Jupiter orbiter and probe. This challenging mission, scheduled for launch in early 1982, will use the full capability of the Shuttle and provide in depth information on the Jovian atmosphere and its fascinating satellites. A total of $116.1 million is requested to continue Galileo development in Fiscal Year 1980.

Solar/Terrestrial Research will continue at a strong pace with central activities based on the Solar Maximum Mission (SMM), designed to study the energies of solar flares and related events during the forthcoming period of maximum solar activity, and the International Solar Polar Mission (ISPM), planned for launch in 1983, a joint mission with the European Space Agency to give us our first look at the Sun's third dimension by flying two spacecraft using a Jupiter swing-by out of the ecliptic plane of our solar system and over the north and south poles of the Sun.

The Life Sciences program, for which a total of $43.9 million is requested, will emphasize in-flight experimentation, thus taking advantage of the laboratory atmosphere which will be available in the Spacelab.

Space and Terrestrial Applications

We are requesting a total of $344.4 million for Space and Terrestrial Applications programs. No new flight projects are included in this request. The Space Applications Program budget request is $332.3 million. Of this amount, $141.4 million will be applied to Resource Observations Programs, with emphasis on agricultural research and on the continued development of Landsat D. This advanced earth-observation satellite, the fourth in the Landsat series, is scheduled for launch in 1981 with a second-generation, high resolution remote sensing instrument, the thematic mapper, as well as the flight-proven multi-spectral scanner.

A total of $117.2 million is planned for Environmental Observations Programs. With the transfer of the Upper Atmosphere Research Program from the Office of Space Science (OSS) to the Office of Space and Terrestrial Applications (OSTA), environmental research within NASA is

now focused in Space Applications. Major thrusts of the Environmental Observations Program in Fiscal Year 1980 are directed at an understanding of the physics and chemistry of the environment, including changes in stratospheric ozone and halogens, and identification of severe storm precursors. Our long-term goal is, of course, an accurate understanding of our total environment, the atmosphere and oceans which surround us, and how they change in space and time.

A major initiative which will begin in Fiscal Year 1980 is a joint, cooperative program with the Departments of Agriculture, Commerce, and the Interior, and the Agency for International Development in crop monitoring and commodity production forecasting. NASA, building on experience gained in the Large Area Crop Inventory Experiment (LACIE), will develop and test remote sensing techniques to provide both commodity production forecasts and early warning of changes affecting crop production or quality.

The President's space policy directs NASA to support U.S. leadership in communications satellite systems. In the budget request before you today, NASA is proposing to re-enter selected areas of this sector of research and development. We will concentrate on the development of the technology required to increase the usable capacity of the radio frequency spectrum for communications satellites in geosynchronous orbit, including development of multibeam antennas and on-board switching techniques.

Work will also continue on the Search-and-Rescue Demonstrations Project--a joint project with Canada, France, and the USSR--as it progresses toward a 1982 first flight.

In the area of materials processing, the emphasis is on research and experimentation. We have now identified fourteen investigations for early Shuttle missions in such areas as crystal growth, containerless processing and fluid dynamics. We are also reviewing the possibilities for joint ventures, with NASA and private industry.

We are requesting $12.1 million for Technology Utilization as compared to $9.1 million for Fiscal Year 1979. This program continues to provide important benefits to the Nation from aerospace research and development. We plan added emphasis on stronger interaction with the private sector in Fiscal Year 1980. Of the $3 million increase, $2.4 million represents the transfer of Civil Systems Activities into Technology Utilization.

Aeronautics and Space Technology

In Aeronautics, our Fiscal Year 1980 R&D budget request is $300.3 million. Our primary efforts will be directed at strengthening the technology base, continuing progress toward energy-efficient aircraft, and continued noise, pollution and safety research.

Fiscal Year 1980 marks the year of peak activity in our Aircraft Energy Efficiency Technology program with total resources of $116.1 million. The program is aimed at providing improved technology leading to a major reduction in fuel requirements for transport aircraft. In the Energy Efficient Engine activity, components will be designed, fabricated and tested for a next generation, high-bypass turbofan engine. In the Energy Efficient Transport area, we will continue our efforts with the major airframe manufacturers to advance the technologies of aerodynamics and active controls for new and derivative subsonic transport aircraft. Wind tunnel models will be evaluated in the Laminar Flow Control (LFC) activity, and the design of a full-scale LFC wing will be underway.

Rotorcraft technology efforts will stress discipline advances to improve terminal operations, efficiency and flightworthiness. General aviation activities will focus on noise and emission reduction, crashworthiness and advanced low-cost avionics systems. Technology for vertical-takeoff-and-landing aircraft and high-performance aircraft will be conducted primarily in support of current and future military requirements.

A strong generic research and technology base has been the foundation of this country's leadership in aviation. In order to meet the ever-increasing challenge of competition from abroad, we must invest in the disciplinary areas of materials, structures, propulsion, avionics, and aerodynamics, upon which advanced aircraft will be developed. We propose a total of $117.5 million for these activities.

Our Space Research and Technology Program for which we are requesting $116.4 million for Fiscal Year 1980, will continue to support the needs of current and future space missions and to formulate approaches which will increase the reliability and efficiency of future missions. A broad spectrum of advanced technology disciplines will be supported, including propulsion, structures and materials, and communications.

A total of $3 million is proposed for continued work to identify the technology generated in our aeronautics and space program which has potential for major contributions to the solution of our energy problems. We also will continue our high successful efforts in support of the Department of Energy (DOE) in such areas as solar cells, solar heating and cooling, and wind machines. I am pleased to note that the President is requesting $8 million for DOE on solar power satellite research in Fiscal Year 1980, an increase of $3.5 million. We will continue our joint study efforts with DOE in this area, with NASA continuing its systems definition efforts on a reimbursable basis.

Space Tracking and Data Systems

We are requesting a total of $332.8 million for continuation of tracking and data acquisition support for earth-orbital spacecraft, planetary missions, sounding rockets, and research aircraft. The Fiscal Year 1980 workload remains high, with the Spaceflight Tracking and Data Network supporting an average of approximately 50 earth-orbital applications and scientific spacecraft, and the Deep Space Network supporting a full complement of planetary missions, including Pioneers 6 through 11, Helios 1 and 2, Voyagers 1 and 2, and Pioneer Venus.

A major aspect of the Tracking and Data Acquisition program in future years will be the Tracking and Data Relay Satellite System (TDRSS), which will replace most of our ground-based stations, and will support essentially all earth-orbital tracking and data acquisition capabilities in the Shuttle era.

Construction of Facilities

For Construction of Facilities, we are requesting a total of $157.6 million, an increase of approximately $10 million over Fiscal Year 1979. Of this total, $12 million is for completion of construction of the National Transonic Facility begun in Fiscal Year 1977 at the Langley Research Center. This unique facility, by employing a cryogenic test medium, will allow testing of a broad spectrum of vehicles at full-scale Reynolds numbers and will serve the research needs of NASA as well as the development test needs of DOD and the aerospace industry for years to come.

Also included is $33.9 million to continue the modification of the 40 x 80 foot Subsonic Wind Tunnel at the Ames Research Center. This facility will permit the testing of rotorcraft at speeds up to 300 knots, as well as

full-scale testing of vertical- and short-takeoff-and-landing (V/STOL) aircraft, including large rotorcraft in the new 80 x 120 foot test section.

A total of approximately $31.5 million is requested for Space Shuttle facilities, primarily related to launch and landing requirements at the Kennedy Space Center and the external tank manufacturing and final assembly areas at the Michoud Assembly Facility in New Orleans.

Research and Program Management

Research and Program Management funds the performance of research, technology and test activities at NASA Centers, and the planning, management and support of contractor research and development activities necessary to meet the Nation's objectives in space and aeronautics research. The civil service personnel funded by this line item represent NASA's most important resource and are the strength on which our world leadership in space and aeronautics depends. Three-fourths of this appropriation is required for their salaries and related costs. About two percent is for travel which is vital to the management of our R&D programs. The balance is for facility support and related goods and services. Our request for Fiscal Year 1980 totals $964.9 million.

The austerity of the Fiscal Year 1980 budget, as well as the Congressional mandate in the Civil Service Reform Act for reducing Federal manpower levels in Fiscal Year 1979, necessitate an overall reduction of 674 in the NASA permanent civil service personnel ceiling. This reduction will be phased through Fiscal Years 1979 and 1980. Each field installation and NASA Headquarters is now reviewing the least disruptive approach to reaching the newly assigned levels. The NASA permanent civil service manpower ceilings will be reduced to 22,831 by the end of Fiscal Year 1979, and 22,563 by the end of Fiscal Year 1980. This compares to a workforce of about 35,000 civil servants in the late 1960s.

Summary

In conclusion, I believe the President's budget request comprises a sound, balanced aeronautics and space program. This request provides a good but tightly constrained foundation for meeting the stated goals of the civil space policy and will permit the United States to maintain its leadership in space science, applied technology, and aeronautics. It also fully supports the continued development of the Space Transportation System, meets commitments made

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in the past, maintains progress in ongoing programs, and provides for some flexibility in future programs. The President's Fiscal Year 1980 budget request is tight, but sufficient to continue our transition to the Shuttle era in a time of fiscal stress.

Mr. Chairman, I have touched upon the highlights of our Fiscal Year 1980 request, and would be happy to try to answer whatever questions the Subcommittee may have.

# # # # # #

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET SUMMARY
(Thousands of dollars)

BUDGET PLAN	FY 1978	FY 1979	FY 1980
Research and development	3,011,600	3,477,200[a/]	3,602,500
Construction of facilities	162,340	147,500	157,600
Research and program management	889,506	941,469[b/]	964,900
TOTAL BUDGET PLAN	4,063,446	4,566,169	4,725,000
OUTLAYS	3,983,119	4,404,100	4,595,000

a/ Includes proposed supplemental of $185,000,000 for the Space Shuttle.

b/ Includes proposed supplemental of $30,969,000 for October 1978 pay increase.

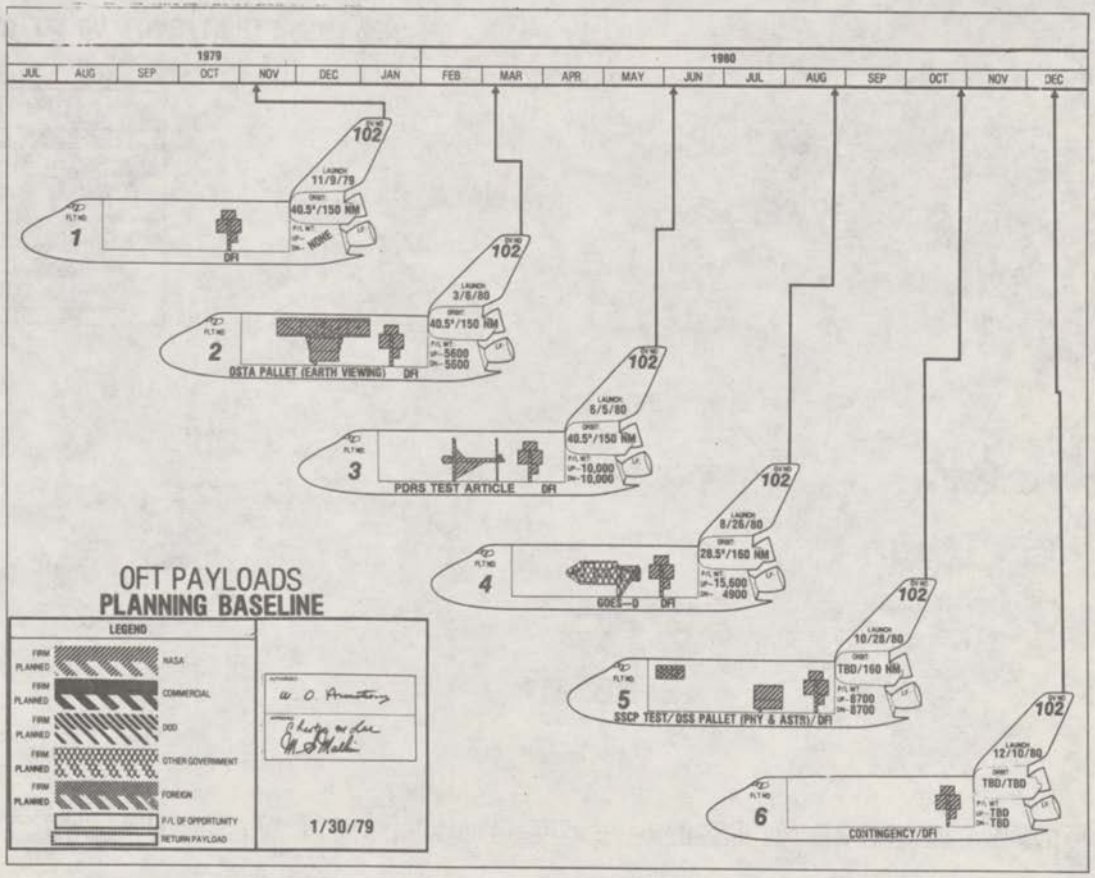
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

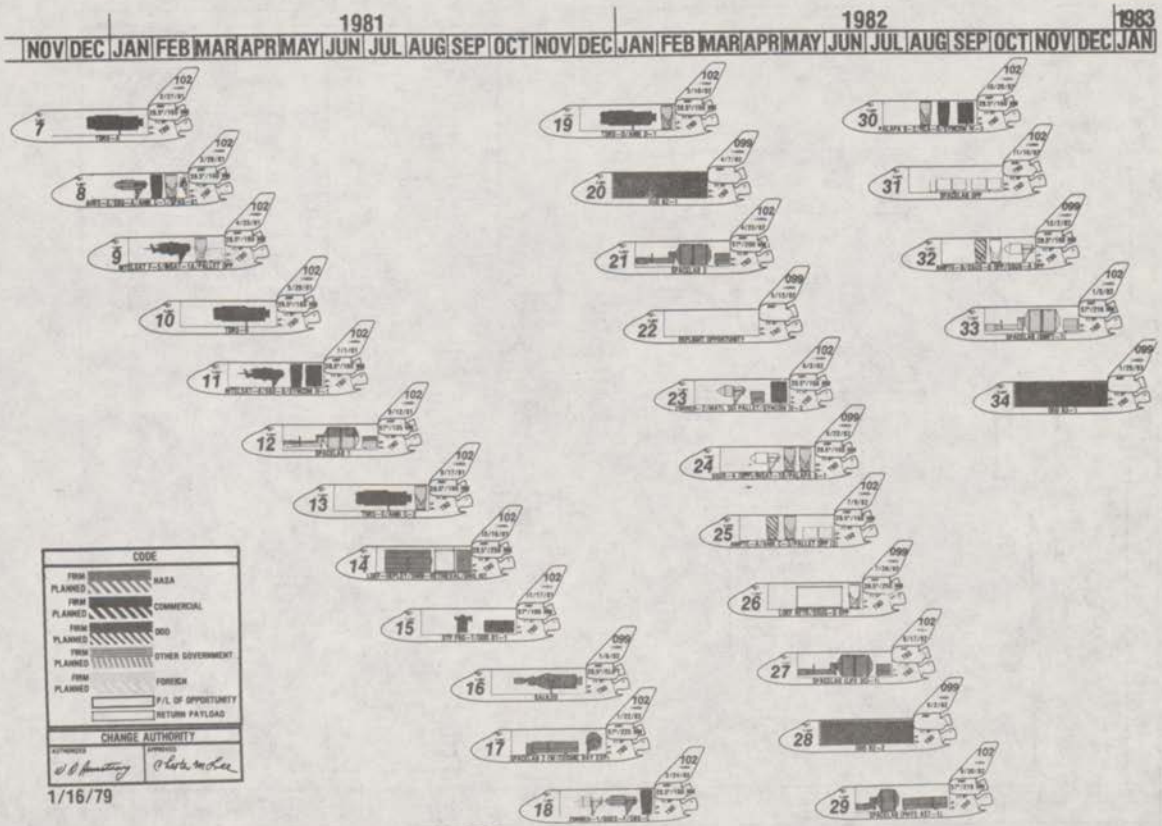
RESEARCH AND DEVELOPMENT PROGRAMS

BUDGET PLAN
(Thousands of Dollars)

Cognizant Office and Program	FY 1978	FY 1979	FY 1980
SPACE TRANSPORTATION SYSTEMS	1,751,500	2,009,500	1,904,000
Space Shuttle	1,349,200	1,628,300[a/]	1,366,000
Space flight operations	267,800	309,700	467,300
Expendable launch vehicles	134,500	71,500	70,700
SPACE SCIENCES	404,700	505,400	601,600
Physics and astronomy	224,200	282,900	337,500
Planetary exploration	147,200	182,400	220,200
Life sciences	33,300	40,100	43,900
SPACE AND TERRESTRIAL APPLICATIONS	243,900	283,900	344,400
Space applications	234,800	274,800	332,300
Technology utilization	9,100	9,100	12,100
AERONAUTICS AND SPACE TECHNOLOGY	333,200	376,400	419,700
Aeronautical research and technology	228,000	264,100	300,300
Space research and technology	97,700	107,300	116,400
Energy technology	7,500	5,000	3,000
SPACE TRACKING AND DATA SYSTEMS	278,300	302,000	332,800
TOTAL	3,011,600	3,477,200	3,602,500

a/ Includes proposed supplemental of $185,000,000


1979
JUL
AUG
SEP
OCT
NOV
DEC
JAN
1980
FEB
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APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1
LAUNCH 11/9/79
40.5°/150 NM
DFI
2
LAUNCH 3/6/80
40.5°/150 NM
OSTA PALLET (EARTH VIEWING) DFI
3
LAUNCH 6/5/80
40.5°/150 NM
PDRS TEST ARTICLE DFI
4
LAUNCH 8/26/80
28.5°/160 NM
GOES-D DFI
5
LAUNCH 10/28/80
TBD/160 NM
SSCP TEST/OSS PALLET (PHY & ASTRI)/DFI
6
LAUNCH 12/10/80
TBD/TBD
CONTINGENCY/DFI
OFT PAYLOADS
PLANNING BASELINE
LEGEND
NASA
COMMERCIAL
DOD
OTHER GOVERNMENT
FOREIGN
P/L OF OPPORTUNITY
RETURN PAYLOAD
1/30/79



1/16/79

SHUTTLE PAYLOAD FLIGHT ASSIGNMENTS

Mr. BOLAND. All right, you have given us your general statement.

Dr. FROSCH. I would like to read substantial parts of it. I would like to go through the introduction and then ask Dr. Lovelace, the Deputy Administrator, to describe some of the highlights of the preceding year to the Committee.

INTRODUCTION OF NASA WITNESSES

Mr. BOLAND. Will you introduce the other NASA witnesses?

Dr. FROSCH. Yes, sir, I am about to do that.

Mr. BOLAND. First, I would like to introduce Bennett Stewart, who is one of the new Members of the Subcommittee from the State of Illinois.

Dr. FROSCH. Let me start on my left with Mr. Arnold Frutkin, who is not new to NASA, but new appearing for this Committee in his current capacity as Associate Administrator for External Relations. Next to him is Dr. Bill Schneider, also not new to NASA, but new to his current position of Associate Administrator for Space Tracking and Data Systems. Next is Mr. Robert Allnutt, who was with NASA for a number of years, has been elsewhere in the government, and is now back as Associate Deputy Administrator.

On my right, you know Dr. Alan Lovelace, who is the Deputy Administrator; Mr. Bill Lilly, who is the Comptroller of NASA; and Mr. John Yardley, who is the Associate Administrator for Space Transportation Systems.

Behind us, on my left, is Ray Kline, who is the Associate Administrator for Management Operations. Next to him is General Bill McGarvey, who is the Director of Facilities; then Jim Kramer who is the Associate Administrator for Aeronautics and Space Technology; and Tony Calio, who is the Associate Administrator for Space and Terrestrial Applications. Also here are the Deputy General Counsel, Gerry Mossinghoff, and Dr. Noel Hinners, who is the Associate Administrator for Space Science.

Mr. BOLAND. I am glad you brought Noel Hinners, who has appeared here before and always does a fine job. Please proceed.

Dr. FROSCH. The others are Mr. Tommy Newman, who is the Deputy Comptroller of NASA, Dr. Harriet Jenkins, who is the Director for Equal Opportunity Programs, and Terry Finn, who is the Director of our Legislative Affairs Office.

Mr. BOLAND. How are you doing in equal opportunity, Dr. Jenkins?

Dr. JENKINS. NASA continues to make meager, modest progress, despite the fact it has fewer opportunities to hire, and we have a decreasing civil service level.

Dr. FROSCH. It is hard to make changes when you cannot hire people.

Mr. BOLAND. That is true.

Dr. FROSCH. That is the easiest way to state it.

Mr. BOLAND. But don't tell me about having over 34,000 personnel back in the late 1960's, and now you don't have that many.

A decade ago you were impacted by Apollo, but that is no longer the case, as you know. However, in the budget the reduction looks good to somebody who isn't familiar with NASA's history.

Dr. FROSCH. We do continue to decrease in size.

Mr. BOLAND. I know you do.

Dr. FROSCH. And it is a long time since Apollo.

Mr. BOLAND. We think NASA is a well-run agency, and we have said so often. You get more for the dollar than most people do.

SUMMARY OF GENERAL STATEMENT

Dr. FROSCH. Thank you, Mr. Chairman.

It is a pleasure for me to present today the President's request for appropriations for Fiscal Year 1980 for the activities of the National Aeronautics and Space Administration. We are requesting a total of $4.725 billion for Fiscal Year 1980. Additionally, we are requesting a supplemental appropriation of $185 million for Space Shuttle design, development, test, and evaluation for Fiscal Year 1979, which I will also discuss in this statement.

In October of last year in a speech at the Kennedy Space Center, the President outlined his space policy for the coming decade. The policy enunciates a vigorous civilian space program centered on the proposition that the United States will retain scientific and technological world leadership in space activities. The policy, as well as the budget request we bring before you today, emphasizes the Administration's commitment to the completion of the Space Transportation System, followed by exploitation of the flexibility and unique opportunities this system will provide through routine, economical access to Earth orbit and return.

In Space Science, building on the base establishing by prior appropriations, the policy calls for continued exploration of the planets, exploring the far reaches of the universe, and examining, in depth, the effects of the Sun on the Earth's environment. In Space Applications the policy supports continued activity in the acquisition of data by remote sensing, including efforts toward an operational remote sensing system and work on a new agricultural inventory research initiative. We will also renew our research and development efforts in selected areas of communications technology.

Inflation continues as the country's most pressing problem, and the President's total budget, designed to reduce the Federal deficit to less than $30 billion, is tight and austere. In this context, the NASA budget for Fiscal Year 1980 of $4.725 billion, and the Fiscal Year 1979 supplemental request of $185 million for the Space Shuttle, represent, I believe, a strong Administration commitment to civil space and aeronautics programs. This budget includes no new major flight project starts. However, the multiyear budget projection process has established future fiscal year targets for NASA which offer some flexibility in the selection of new efforts over the next several years.

From an overall standpoint, excluding the supplemental request for the Space Shuttle, the budget total represents an increase over Fiscal Year 1979 of 7.8 percent, which is about equal to inflation. When the Fiscal Year 1979 supplemental amounts requested for the Space Shuttle and the Civil Service pay increases are taken into account, the total increase is about 3.5 percent.

Mr. Chairman, if I may at this point, I would like to ask Dr. Lovelace to present the highlights of the previous year.

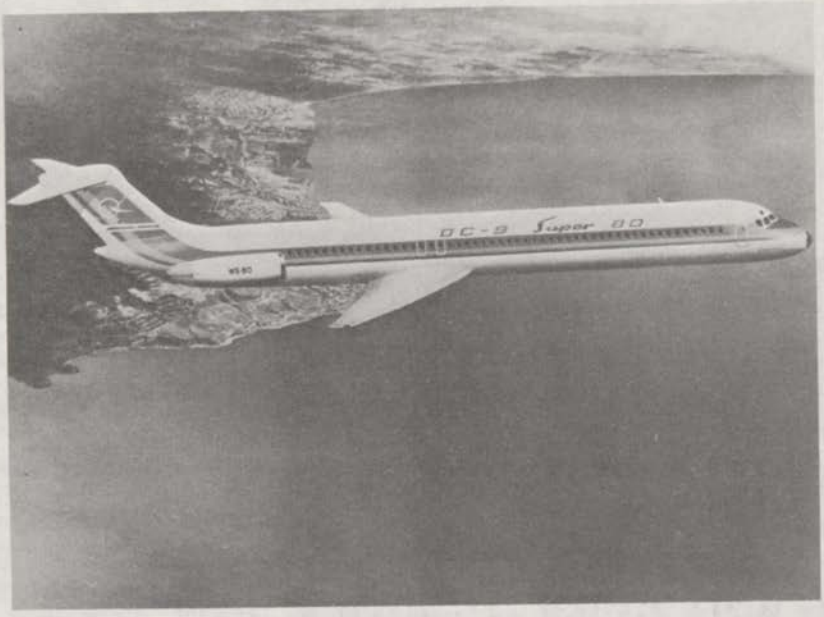
Mr. BOLAND. We are delighted to have you, Dr. Lovelace.

Dr. LOVELACE. Mr. Chairman, if I could call your attention to the material in front of you and each of the Members, I would like to present some highlights of our 1978 accomplishments:

NASA

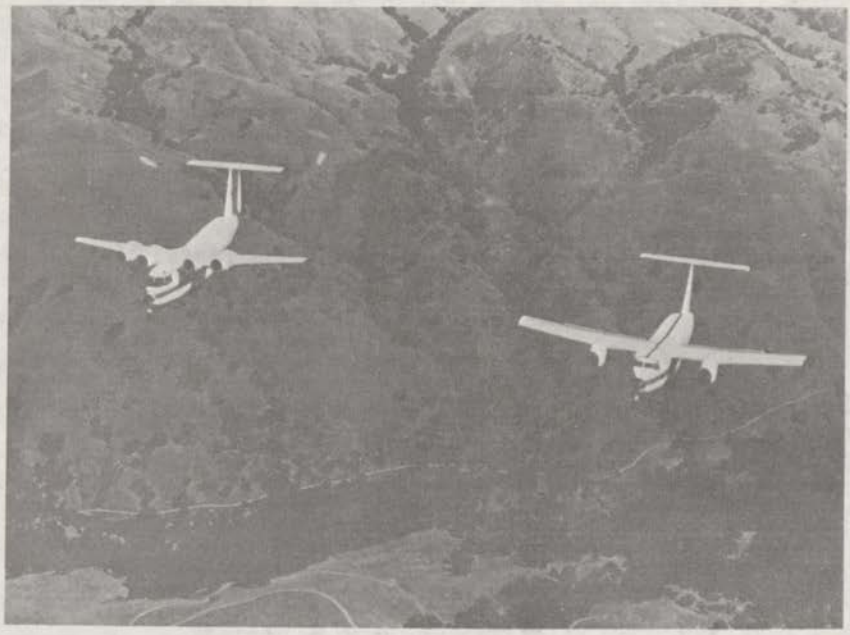
National Aeronautics and Space Administration

1978 was a busy year, with intensive activity in the Space Transportation System, leading up to the last year of development for the Shuttle's first orbital flight test. During 1978, progress continued in several key areas of our Space Applications Program, and it was certainly a very vigorous and productive year in Space Science. We also saw some of the basic aeronautics work come to fruition. I would like to start in reverse order and highlight these accomplishments for you.



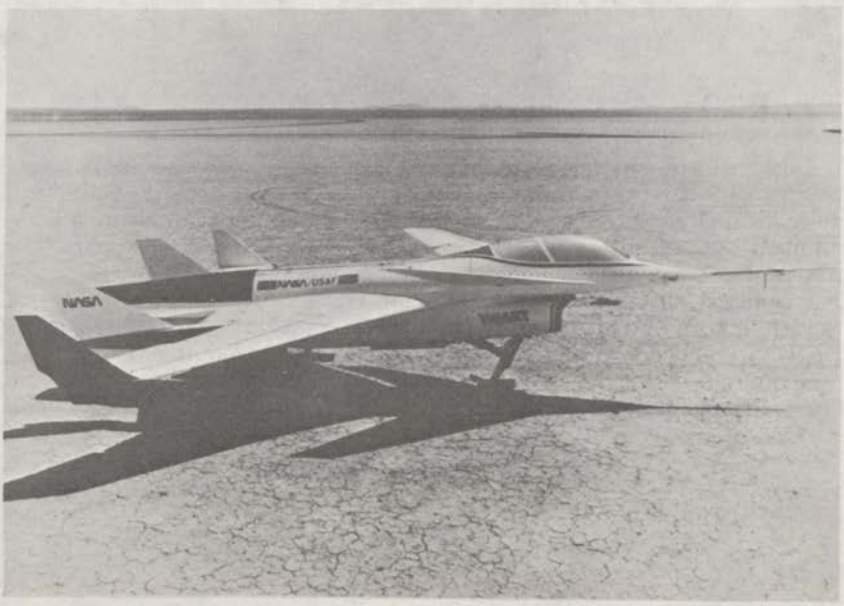
The first illustration shows you a picture of the DC–9 Super 80, which is an aircraft being built for delivery in 1980. It incorporates the basic results of several NASA technology programs in digital avionics, as well as the NASA Refan activity. That aircraft, when it comes into use, will demonstrate a fuel consumption that is probably the lowest per passenger mile of any commercial jet, while still meeting all of the noise reduction requirements.

The next illustration shows you one of our new research aircraft, in the left-hand corner. The four-engine research aircraft is one of two that we took delivery on in 1978. It is part of our quiet Shorthaul Research Aircraft efforts.



Just to give you an appreciation of what that kind of technology can do, it would permit a 727 size aircraft to take off in one third the length of the runway and at a noise level 30 times quieter than our conventional turbofan driven aircraft.

In addition, as shown in the next illustration, we took delivery of two of those 15 feet long remotely piloted vehicles, which we call HiMat—Highway Maneuverable Aircraft Technology demonstrators.



This is a joint U.S. Air Force and NASA activity designed principally to explore the technologies of high speed and manueverability.

Let me now turn to our Space activities. During 1978, the United States launched 34 space missions; 20 of these were launched by NASA. I might point out that we had another 100 percent-successful year with our Expendable Launch Vehicles.

1978 SPACE FLIGHT ACTIVITY

SUCCESSFUL U.S. SPACE MISSIONS 34

NASA 20

NASA FUNDED 8

COOPERATIVE 2

REIMBURSED 10

U.S. GOVT 2

U.S. COMMERCIAL 3

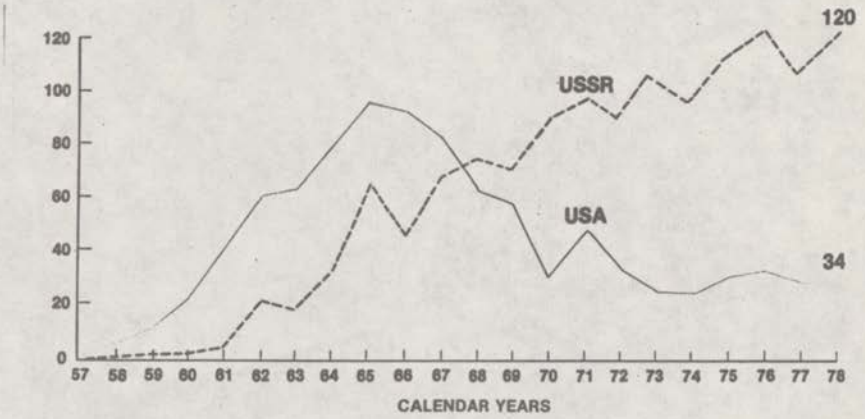
FOREIGN 5

DOD 14

Eight of the twenty were NASA missions. Two were cooperative programs with ESA. Ten were reimbursable programs. I would call your attention to the fact that the activity in geosynchronous communications satellites was very heavy during this past year. The remainder were Department of Defense-launched payloads.

I contrast that, as we have in prior years, with the launch rate of the Soviets. You can see that in 1978, contrasted against our 34, the USSR launched 120 payloads. I would hasten to point out, however, that our payloads are more sophisticated, carry multiple sensors, and are multi-purpose satellites. In that regard, it is really an unfair comparison to make quantitatively.

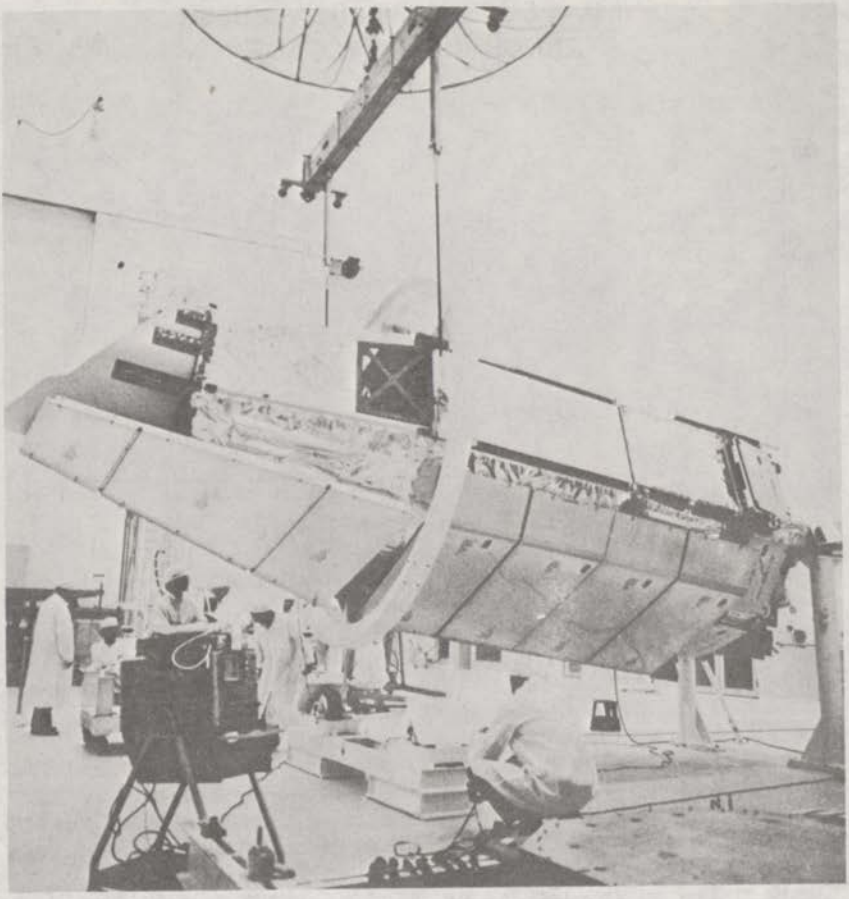
ANNUAL SUCCESSFUL USA & USSR ANNOUNCED PAYLOADS

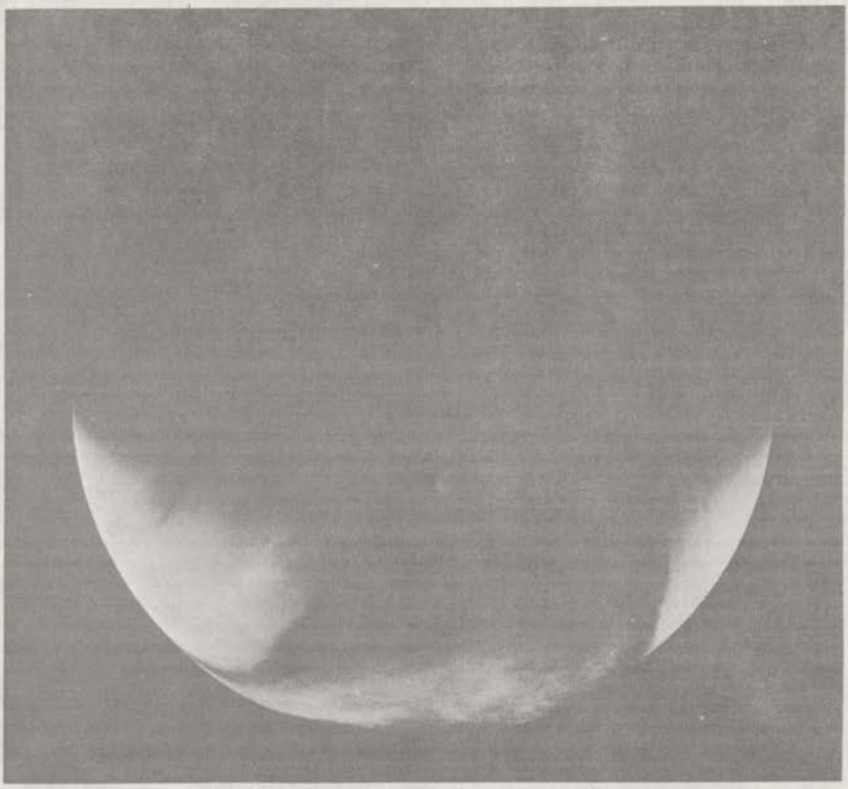


Let me now turn to Space Science. Illustration six shows HEAO-2, the second of a pair of satellites that have been in orbit, looking at galactic and extra-galactic x-ray sources. This one was launched last November. The third HEAO will be launched this year.

The two HEAO satellites in orbit have, among other phenomena, discovered two possible new black holes that will be of great interest to the science community.

In addition, the Pioneer Venus Orbiter and Probe Missions arrived in December at Venus. One spacecraft released four probes, which descended through the dense atmosphere of Venus to its surface and provided excellent scientific data. One of them lasted for over an hour. You see here a cloud cover image taken from the Pioneer Venus Orbiter on Christmas Day, at about the same time, as a matter of fact, as the Soviet probes were placed on that same planet.



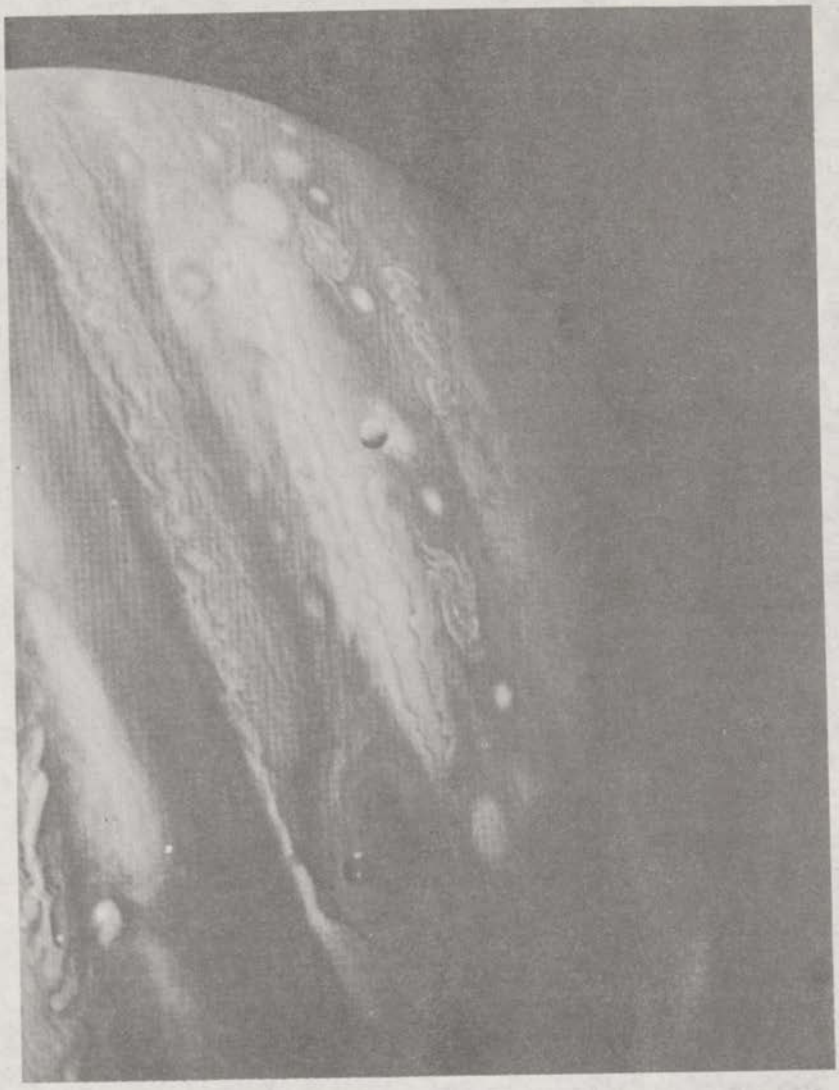


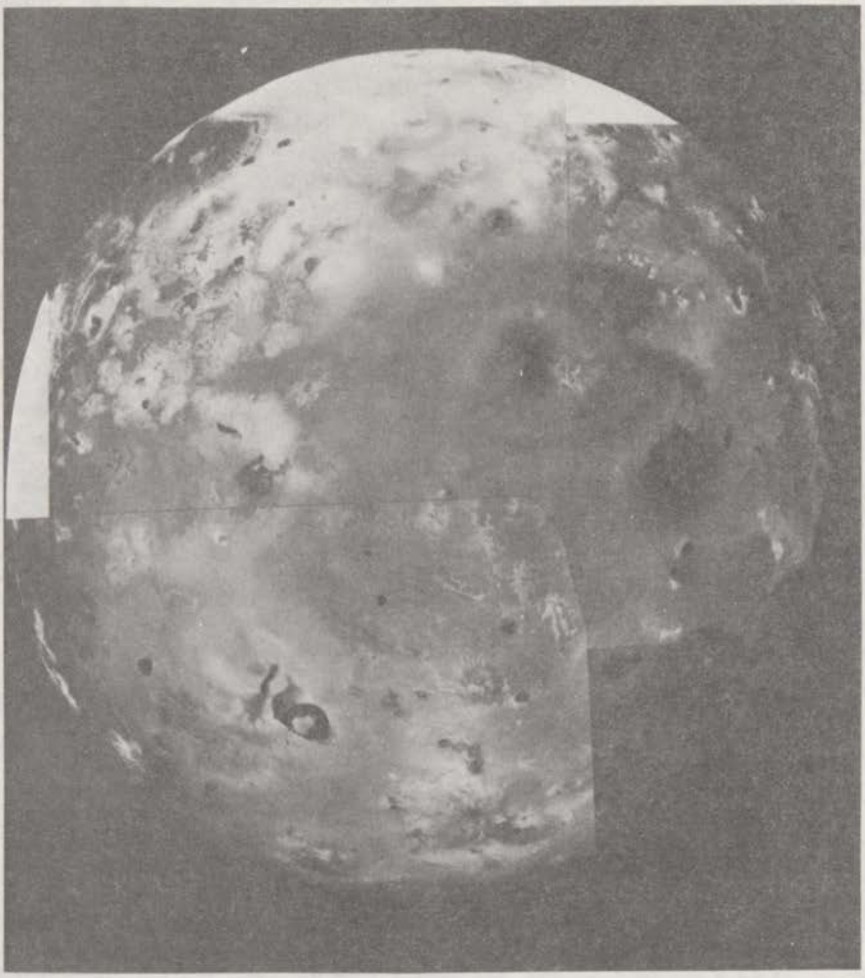
VOYAGER 1 JUPITER PROBE

Venus was not the only planet that we visited. As you are, I know, aware, the Voyager 1 spacecraft has encountered Jupiter, as seen in illustration eight, which shows two of the Galilean satellites—Io on the left, and Europa on the right. We experienced the closest approach to Jupiter just yesterday morning, March 5.

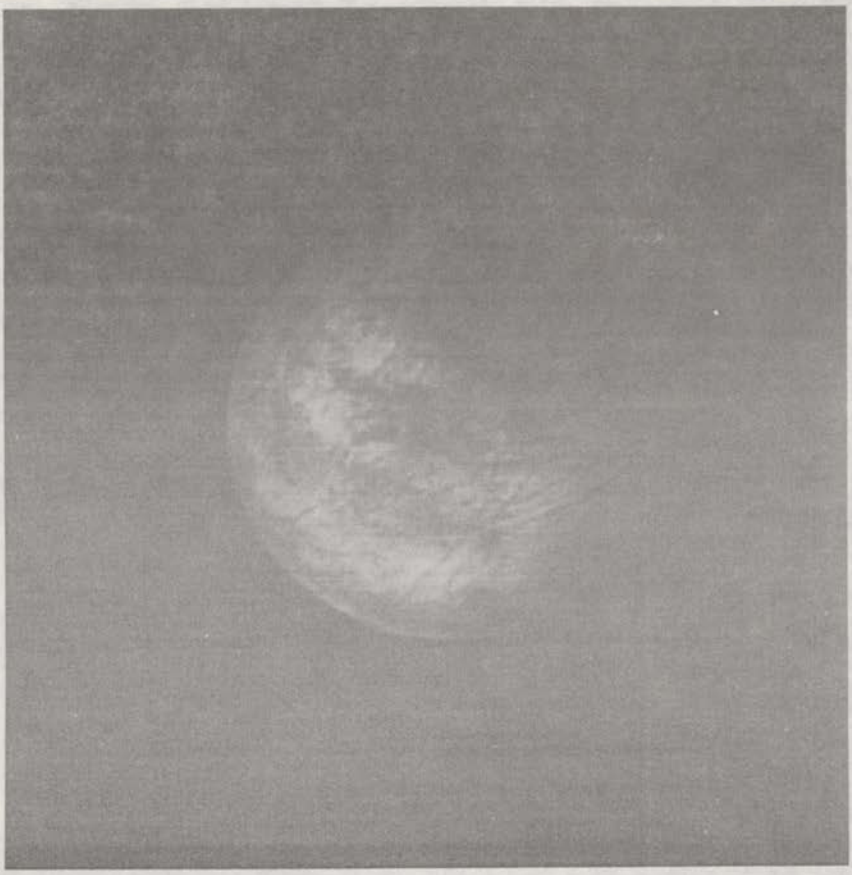
We thought you might be interested in three very recent photographs of Io, Europa, and Ganymede. I think you saw those of Europa coming in on the black and white screen yesterday morning, March 4th.

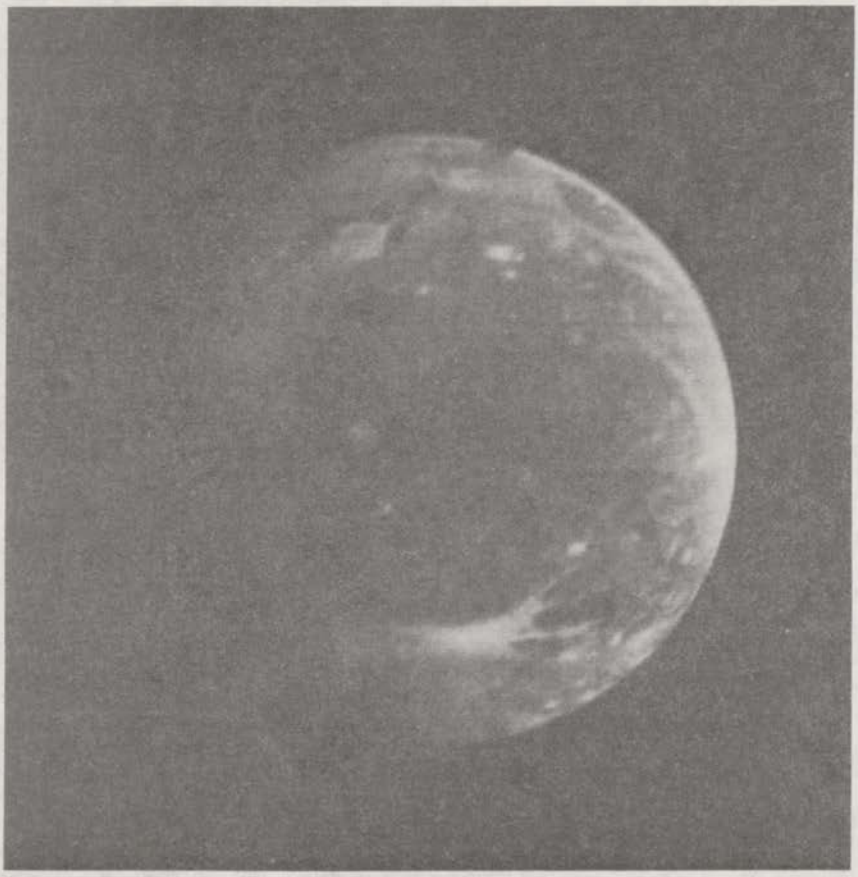
Dr. FROSCH. And the day before.





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Dr. LOVELACE. This is the satellite Ganymede, also taken by Voyager 1. Those pictures came out just about 9:00 p.m. yesterday.

We have pictures of Collisto, that came in this morning about 10:00, but we have not yet had time to synthesize those color composites. We certainly will get one of those up to the Committee to look at as soon as that synthesis is done.

SATELLITE APPLICATIONS ACTIVITY

Let me turn now to our Applications activity. The next illustration shows you data collected from our Heat Capacity Mapping Mission, the HCMM satellite. What you are looking at is an image that it made up, in effect, by a remote thermometer measuring the temperatures of the earth and water from space. It can do this at night and during the day, and you can contrast the two. This image runs from Cape Hatteras up to Lake Ontario.

The temperatures are color-coded—from purple, the coldest, to blue, green, brown, yellow, orange and white, the hottest, which is shown by New York City.



You can see the Gulf Stream in the right-hand corner. It is warmer than the surrounding Atlantic Ocean. Lake Ontario and Lake Erie, are at the top—very, very cold and shown in dark purple.

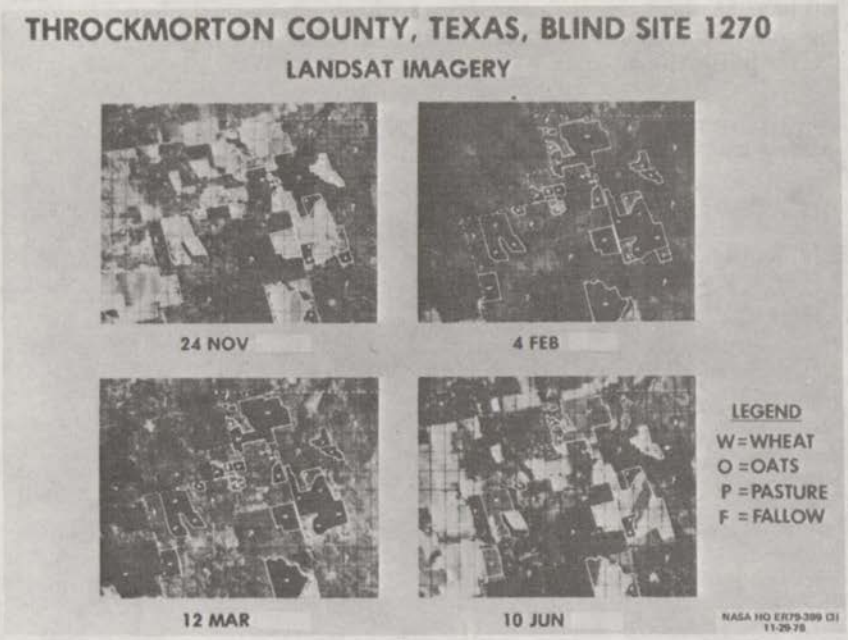
The data show promise for more accurate geological identifications, for water studies and for examination of crop health, just to mention a few applications.



We also launched, in October, Tiros-N, the satellite shown in illustration 10. This is a NASA-funded research prototype of the next generation weather satellite series that will be built and launched for NOAA on a reimbursable basis.

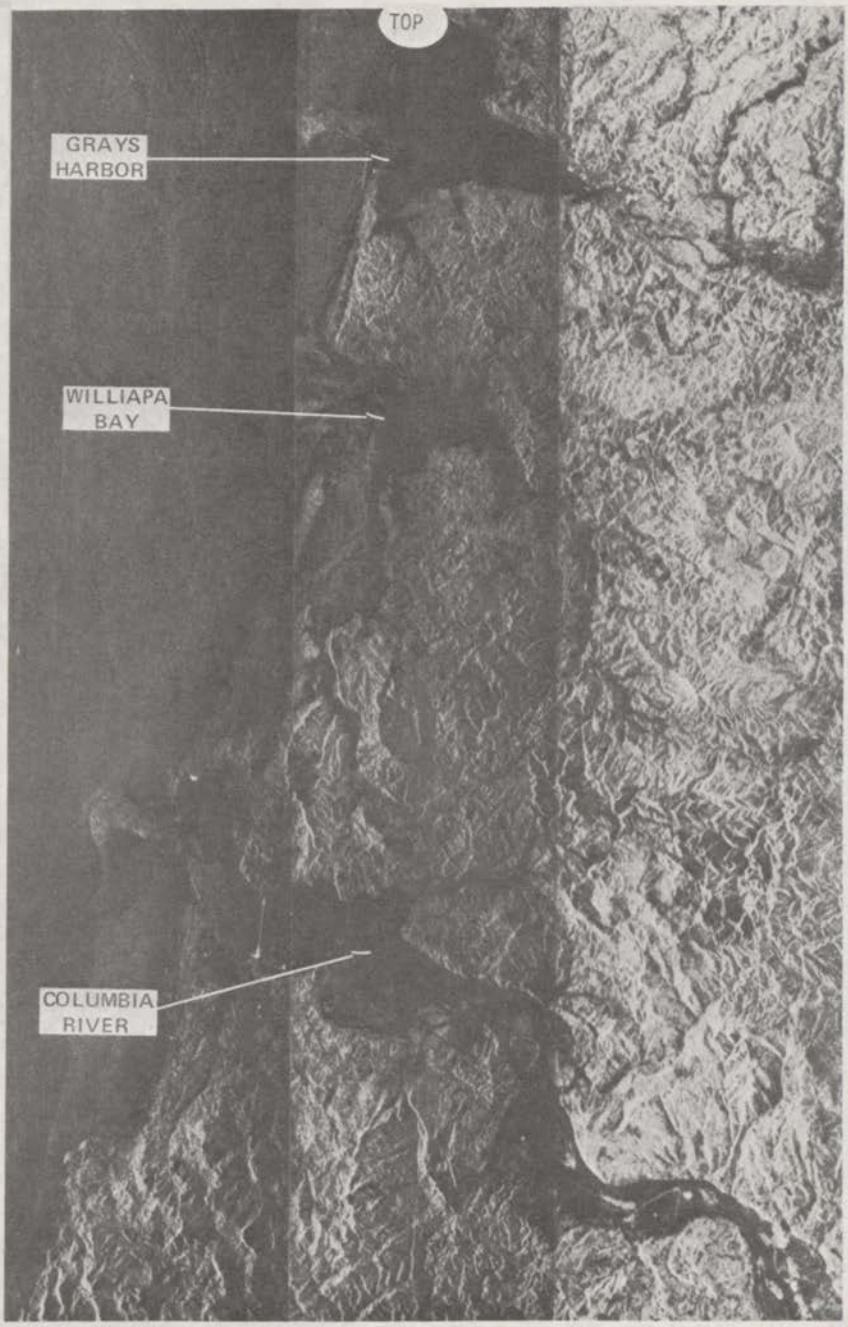
Tiros-N, plus other satellites, are major contributors to the Global Atmospheric Research Program in the first global experiment that is in process now. Through the more accurate instruments contained on this spacecraft, it is hoped that numerical weather forecasting can be substantially improved from what we have today.

In 1978 we also completed the Large Area Crop Inventory Experiment. Illustration 11 shows the kind of repetitive data that was used to demonstrate that the U.S. Department of Agriculture's crop accuracy requirements for crop size, could be met by the Landsat resolution, where we knew the grain mix for that particular area.



This experimental program, conducted in conjunction with the Department of Agriculture and NOAA, and using weather satellite data, has helped us define hardware and software improvements that are needed for an expanded worldwide system. This effort is addressed in our FY 1980 budget request.

We also launched, in June, SEASAT, the first oceanographic research satellite. As you observed, we suffered a power failure after 106 days of operation. I would like to point out, however, that we achieved about 75 to 80 percent of our research objectives. What you are seeing here are the results of only one of the instruments that was on-board SEASAT. It is a synthetic aperture radar picture of the Washington and Oregon coast. You can see the detail. Back at the Columbia River you can see the white line, which is the bridge across the Columbia River. But, more important, is the ability of the radar to detect salinity, ocean conditions, and sea surface conditions, and in some of the bays, such as Willapa Bay, you can even see the tidal flows in the Bay and out into the Pacific Ocean. You can also see what may be subsurface waves in the upper part of the Pacific out there. It will take us many months to extract the very useful data acquired from that instrument alone.


TOP
GRAYS HARBOR
WILLIAPA BAY
COLUMBIA RIVER

VIABILITY OF WIND GENERATED ENERGY

In the Energy area, we conducted, for the Department of Energy, and with their funds, over $100 million of research in 1978. I will highlight a few key areas.



One of them is the second wind generator that was built. Is is located at Culebra, Puerto Rico. The first was constructed in Clayton, New Mexico and has been operating successfully for a year. The Culebra System was just put in to service last year, and is providing electrical power to the inhabitants of the Island of Culebra.

Mr. BOLAND. How many inhabitants are able to benefit from the wind generator?

Dr. LOVELACE. I don't know the exact number of inhabitants, Mr. Chairman, but at peak power this machine can provide about 80 percent of the minimum power requirements for the island of Culebra, and it operates at between 20 and 80 percent load, providing 20 to 80 percent of the power required for that island.

Mr. BOLAND. You only operate it at peak conditions?

Dr. LOVELACE. No, sir, it is continuous—it is continuous, and to my understanding—and maybe Dr. Kramer has more data on this, the tradewinds down there make this device function more or less on a continuous basis. It is put into the network and it provides additional, supplemental electricity to the power already available on the island.

Mr. BOLAND. Is this a viable program in really helping us to meet the energy problem that is facing us?

Dr. LOVELACE. My perception, Mr. Chairman, is that it is a viable program. It will in time provide a fraction of the requirements for electrical power in those parts of the world that have the suitable wind conditions.

It is never going to be providing a major fraction of the electrical power that this country is going to need.

Mr. BOLAND. Is it worth the cost?

Dr. LOVELACE. I think that it is.

Mr. BOLAND. What does a station like that cost? You may supply it for the record if you don't have it.

Dr. LOVELACE. I do not know. We can supply it for the record. The data that we acquire from these goes back into the Department of Energy for the sort of economic analyses that you are probing. But, for certain areas, this proved to be a very effective technique.

Mr. MCDADE. Could you put the figures down on the cost? Could you put in the cost-per-kilowatt hours?

Dr. LOVELACE. Yes, sir.

[The information follows:]

Question. What does a station like that cost?

Answer. The cost for development, installation, and initial operation of the Culebra Island wind system was $1,750,000. If this type of system were modified and improved and put into mass production, it is estimated that each unit would cost $200,000.

Question. Could you put the figures down on the cost? Could you put in the cost per kilowatt hour?

Answer. The cost of electricity for the Culebra Island wind system is 35¢/kilowatt hour. An improved machine in mass production is estimated to produce electric power for 4–5¢/kilowatt hour.

Mr. BOLAND. Go ahead, Dr. Lovelace.

Dr. LOVELACE. The second example that I show you here is an Opel which was modified to incorpate a Stirling cycle engine. The Stirling cycle engine is an engine which we have not had much experience with

in this country. It is being evaluated against other improved internal combustion engines and other cycles. This is a demonstrator that we put together for that purpose for the Department of Energy. Based on the results of that evaluation, decisions will be made about whether this is technology that merits investment by the U.S. industry.



SINGLE PHASE MOTOR POWER FACTOR CONTROLLER

I would like to mention one other point before I discuss the Shuttle status.

From our Technology Utilization program, we have a device which we call a power factor controller. We brought a demonstration item that we use, but there is not time to demonstrate is now. It is a device that was developed by an engineer at our Marshall Space Flight Center. He was working on a Solar Heating and Cooling Demonstration program for DOE. This device, in effect, plays on the fact that all AC induction motors that are used in domestic and industrial operations in this country demand nearly as much electrical power when they are idling as when they are under load conditions.

If one can sense the power requirements for the motor in a specific application, and control that power—which is what this device does—one can save about six to eight percent of that electricity at peak power, and something like 25 percent when it is idling.

When you consider that about 64 percent of the electrical energy produced in this country is used to drive electric motors, alternating current motors like this, one can really see great savings to be derived

from applications of this kind of technology. For example, there are about 50 million refrigerators in this country. If this technology were used to control the power to refrigerators, one could save electrical energy equivalent to 11,000 barrels of oil a day. At about $14 a barrel, this amounts to something like $56 million a year—just on that application alone.

We are working with the industry to see this item produced, and it looks as if it can be produced in quantities at prices from $5 to $15 per unit.

Mr. BOLAND. You don't have to hook it on to every single electrical appliance, do you?

Dr. LOVELACE. You could hook it to every single electrical appliance that uses an induction motor.

Mr. BOLAND. You wouldn't want to do that, though?

Dr. LOVELACE. For the ones that have motors.

Mr. BOLAND. I see.

Dr. LOVELACE. Or you could have it installed in the factory as a power controller when a device was produced, and that is probably the cheapest way to install it. You could do that, for example, on sewing machines, and washing machines, and refrigerators. Those units at those volumes are anticipated to cost something like $5 a copy. The savings, I think, would pay for the cost of that device very quickly.

Mr. MCDADE. Would you yield, Mr. Chairman? Dr. Lovelace, did you say the device is ready for commercial application?

Dr. LOVELACE. We are working right now with the industry to commercialize this device, and there are 10 companies with patent licenses now.

Mr. MCDADE. Who owns the patent on this?

Dr. LOVELACE. NASA does.

Mr. MCDADE. Are you familiar with the fellow from the West Coast who showed up at DOE about 3 years ago and had a device that was going to cut the use of electric power on all electrically driven motors by 25 percent?

Dr. FROSCH. That was a change in motor design, rather than a power factor control, wasn't it?

Mr. MCDADE. Yes.

Dr. FROSCH. I don't know any more about it than that.

Mr. MCDADE. The unhappy part of the story is that they took it to the Bureau of Standards and they verified his finding. Then he went to DOE, and got so frustrated that he left town. When last heard of, he was out on the West Coast trying to get private financing. But, I was wondering whether you had any additional information.

Dr. FROSCH. No, Mr. McDade, I don't.

Mr. MCDADE. You say your device is ready for commercial application and we can save six to eight percent on every electrical motor that is driven in this country. What is the price per unit?

Dr. FROSCH. The unit price is $5 to $15, depending on the volume of production and where they are put in.

Mr. MCDADE. We are looking at it now. I serve on another Committee that funds DOE. It had about $30 billion in 3 years, looking for a success story. Have you got one for us?

Dr. LOVELACE. Yes sir, that device is one example.

Dr. FROSCH. We have now licensed 10 companies to produce this device, and we believe that they are going to go into commercial production and start putting it on the market. The most exciting use is in industrial machines, such as drill presses.

Mr. MCDADE. The heavy industry users?

Dr. FROSCH. Yes, the heavy industry users, and not only them but also users who have the motors running all the time whether they are under load or not. The device has been tested in that situation, and all the companies that are licensed believe they will have no difficulty in getting good performance.

Mr. MCDADE. You are already through R&D. There is nothing left to do except to put it on the commercial market for sales?

Dr. FROSCH. That is essentially right, Mr. McDade.

Mr. MCDADE. Tell me, did you get special DOE money, or did I understand you to say that one of your people invented this Power Factor Controller?

Dr. FROSCH. This was done by one of our engineers at Marshall in the course of working on a DOE-financed program to improve the efficiency of solar heating and cooling. One of the problems was to extract as much efficiency as possible out of the circulating pumps that are in certain of those loops. So, the engineer at Marshall devised this scheme for improving the efficiency of the pumps, and then generalized the scheme.

Mr. MCDADE. All right, there is a lot to go over and I don't want to belabor the point now, but could you possibly send me some figures on the cost; how long it takes to save the power; some examples of how it works in a big industrial unit, vis-a-vis the refrigerator elements, et cetera? Could you send that to me in my office?

Dr. FROSCH. Yes, but it has been licensed for appliances that work on single-phase motors, which are typically the ones used in homes. The next stage is to put this type of device into three-phase industrial motors. It probably has to be built into the machine rather than just plugged into the machine.

Mr. MCDADE. You just modify the machine, though?

Dr. FROSCH. With a three-phase machine, you have to get at one point in the internal wiring.

Mr. MCDADE. Would you describe it as a routine modification, or are there some technical problems involved?

Dr. FROSCH. The best way it will get in the industry is for new motors to be built incorporating it, and that involves minor design changes.

Mr. MCDADE. Thank you.

Mrs. BOGGS. Mr. Chairman, may I ask a question? If these are going to be utilized in the home, have we thought about making them, as energy saving components, more attractive by providing tax credits and so on for energy conservation in the home?

Dr. FROSCH. We have not. We have simply produced the technology and tried to get it into a licensed situation.

Dr. LOVELACE. Mr. McDade, I would like to give you that press release, which I think has all of the information that you just asked for, and it has an example. If you would like us to provide more information we will be glad to do so.

[The information follows:]

NASA News

National Aeronautics and
Space Administration

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AC 202 755-8370

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For Release:

WEDNESDAY,
February 28, 1979

RELEASE NO: 79-21

NASA LICENSES ELECTRICITY SAVER FOR HOME AND INDUSTRY

The National Aeronautics and Space Administration has licensed 10 companies to manufacture an inexpensive "space spinoff" invention that has the ability to substantially reduce (in some cases as much as 50 per cent) the amount of energy consumed by the billions of electric motors used in homes and industry throughout the nation.

One licensee has advertised the device for $13.60 and another has estimated that it could incorporate the invention in a one-half horsepower motor for as little as $5.00.

The device, called a Power Factor Controller, was invented by Frank J. Nola, an engineer at NASA's Marshall Space Flight Center, Huntsville, Ala., while trying to find a way to reduce the amount of power necessary for operating solar heating and cooling systems.

The alternate current (AC) induction motors commonly used in homes and industry require almost the same amount of electricity idling (unloaded) as when they are fully loaded. When idling, a large percentage of the power they consume is cast off as heat.

The electricity loss to heat is caused by current flowing through the motor windings and power transmission lines. The amount of this current flow is established by the fixed voltage on which the motor operates -- around 125 volts in most American homes. This particular voltage is supplied by power companies because common household motors are designed for this voltage in order to pull the heaviest loads they are intended to carry. But few of these motors run fully loaded all the time. In fact, many motors run lightly loaded or unloaded most of the time.

The Power Factor Controller, when attached to a motor, continously determines the precise amount of electricity needed by the motor to perform its work efficiently.

It does this by sensing the shifts in the relationship between voltage and current as the motor's workload changes. When it senses a light load, it cuts back the voltage level to the minimum required. This reduced voltage causes current flow to drop as well, markedly reducing the power normally wasted through heat loss.

"A washing machine motor may need nearly 125 volts to operate under a heavy load," Nola explained. "When it's working hard it is probably using about 430 watts of power at that voltage." Of this 430 watt figure, 250 watts do the work and 180 watts are lost in heat.

"When the motor runs unloaded - while water is filling the washer, for example - the total power used drops to about 160 watts. But almost all of this figure is going to heat loss." Though the motor is only idling, heat loss is hardly reduced at all.

The reason, explained Nola, is that even when idling along, the motor still has 125 volts applied to it, creating the same current flow and resulting heat loss as when it is working hard. But as any electrical engineer can tell you, that motor doesn't always need 125 volts. The voltage actually needed varies continuously with the work the motor is doing. But voltage is supplied to your home at a fixed level. So large amounts of power are wasted in millions of electric motors every day.

With a Power Factor Controller on the same washing machine motor described earlier, the overall power usage of an unloaded (idling) motor drops from 160 watts to about 55 watts. Savings are less for a loaded motor, but because most motors never need the full 125 volts provided to your house, the Power Factor Controller can still save about 8 per cent of the power used even when the motor is operating under a heavy load.

The energy savings possible for bigger motors are even more dramatic. "A good example," said Nola, "would be an escalator in a department store. Its big motor always uses a relatively large amount of power to move the escalator even when only one or two people are riding it. The voltage coming in is always the amount needed to move many dozens of people. A Power Factor Controller would limit voltage to only that amount required to move the exact number of people using the escalator at any given time," Nola concluded.

Nola got the idea for his Power Factor Controller while working on a NASA solar heating and cooling project. Most commercial solar systems available today require a number of electrically-powered pumps and fans. Nola's role in the development project being conducted by NASA for the Department of Energy was to try to reduce the amount of auxilliary electrical power needed.

With $30 worth of parts he built a demonstration version of his power controller on a scrap of plywood and hooked it up to a motor like the type used in millions of water pumps. Laboratory tests showed that the device reduced the amount of power used by 6 to 8 per cent while the motors were pulling normal loads, and by about 65 per cent while idling.

The device works on any single-phase, household-type motor by simply connecting it to the wires going to the motor. Many heavier-duty,three-phase motors require a simple modification to accept a controller.

Tests conducted by the School of Engineering at Auburn University, Auburn, Ala., have verified the feasibility of using Power Factor Controllers on many existing household and industrial electric motors.

One test recently conducted by a private firm on an industrial sewing machine with a one-half horsepower, three-phase motor (one of about 3,500 used by the firm) showed the test motor using 33 per cent less power than an identical motor without the device attached. A recent study made for the Federal Energy Administration reports that 64 per cent of all electricity generated in the United States goes to operate electric motors. Thus, the device's potential for achieving energy savings is enormous. (See chart, page 7.)

43-843 O - 79 - 4

The Department of Energy has joined NASA in a cost-sharing development program to evaluate the effectiveness of the Power Factor Controller in industrial applications.

Licensees selected by NASA to manufacture the Power Factor Control System for AC induction motors &(U.S. Patent No. 4,052,648, NASA Case No. MFS-23280) are:

1. Electronic Relays, Inc.
   1438 Brook Drive
   Downers Grove, IL 60515
   Attn: Joseph Pacente
   312/620-4646

2. IVECO (Improvement Via Electronics Co.)
   17402 Coronado Ln.
   Huntington Beach, CA 92647
   Attn: Edward Yrissari, Gen. Mgr.
   714/842-2925

3. W. J. Purcell Co.
   4315 Myrtle Ave.
   Cincinnati, OH 43236
   Attn: Desmond J. Neville, Pres.
   513/791-1131

4. ADELET-PLM Div.
   Scott and Felzer Co.
   4801 W. 150th St.
   Cleveland, OH 44135
   Attn: Maw H. Lee
   216/267-9000

5. Electronic Assemblies Co.
   1601 Hull Street
   Richmond, VA 23224
   Attn: Gerald F. Wilkinson
   804/231-0132

6. Energy Masters, Inc.
   3188 Airway Ave., Bldg. F
   Costa Mesa, CA 92626
   Attn: Palmer B. Ford, Pres.
   714/556-4921

7. N.R.G. Products, Inc.
   P. O. Box 512
   Vineland, NJ 08360
   Attn: Fred L. Hurban
   609/691-6699

8. Clinton Industries, Inc.
   700 Washington Ave.
   Carlstadt, NJ 07072
   Attn: Angelo Pirrello
   201/935-4242

9. Energy Vent, Inc.
   423 Rita Street
   Dayton, OH 45404
   Attn: John Prikkel, P.E.
   513/222-7749

10. Controlled Power Corp.
    2542 237th Street
    Torrance, CA 90505
    Attn: Fred A. Mever, Jr.
    213/539-5440

POWER FACTOR CONTROLLER

Examples of Potential Nationwide Savings

	No. of Units (Millions)	Per Unit Savings (Watts)	Duty Cycle (HRS/Day)	Total Power Savings (Mil. KW-HR/Day)	Total Fuel Savings (Barrels/Day)
Typewriters	5	30	8	1.2	2,000
Industrial Sewing Machine	1	60	16	.96	1,600
Washing Machine	50	36	1 load	1.8	3,000
Dryer	35	55	1	1.9	3,200
Refrigerator	50	13	10	6.5	11,000
Freezer	25	17	10	4.25	7,000
Fan	10	25	10	2.5	4,000

A. At $14 per barrel of fuel oil, total savings is $445,000 a day.

B. Savings to utilities or for air conditioning not included.

C. Fuel calculations based on an energy conversion of 600 KW-HR/Barrel (2 KW-HR/LB.) of fuel oil.

Note:

A photograph to illustrate this news release will be distributed without charge only to media representatives in the United States. It may be obtained by writing or phoning:

The Public Affairs Audio-Visual Office
Code LFB-10, NASA Headquarters
Washington, D.C. 20546

Telephone No: 202/755-8366 Photo No.: 79-H-66

NASA Tech Brief

National Aeronautics and Space Administration

Marshall Space Flight Center, Alabama

MFS-23280
Summer 1977

Save Power in AC Induction Motors

Electronic control loop conserves energy by reducing the voltage applied to lightly loaded motor.

Relatively simple and inexpensive circuitry will improve the power factor and reduce power dissipation in induction motors operating below full load. Power factors as low as 0.1 or 0.2 can exist when such motors are partially loaded or unloaded. When this is the case, relatively large currents flow, and little work is being performed. Hence, I^2R losses will occur at all points in the distribution system, including the motor windings, even though no mechanical power is delivered.

An electronic control system has proved, under tests, capable of raising power factors from 0.2 to 0.8 and resulting in energy savings as shown in Figure 1. The power losses are reduced by sensing the phase lag between the voltage and current. This information is fed to the electronic controller shown in Figure 2. This circuit forces the motor to run at a constant predetermined optimum power factor, regardless of load or line voltage variations (within the limits of the motor).

Voltage is varied by using a solid-state switch (such as a Triac or equivalent), which blocks current in either direction until a gate voltage is applied, at which point it will conduct in either direction. When the gate voltage is removed, the Triac remains on until the current goes through zero. Current does not flow again until the gate voltage is applied again. To vary the RMS voltage applied to a motor, the gate is triggered at a given point during the cycle, and the device switches off as the current goes through zero.

The circuitry in the top half of Figure 2 is a typical phase-control and firing-angle circuit. Voltage V_1 is a ramp waveform with its vertical portion synchronized with the zero crossings of the sinusoidal load voltage; V_2 is a dc error signal; and V_3 is a train of pulses that become wider as the error signal increases. When the pulse is positive, a voltage will be applied to the gate of the Triac.

The error signal is derived in the circuitry in the lower half of Figure 2.

(continued next page)

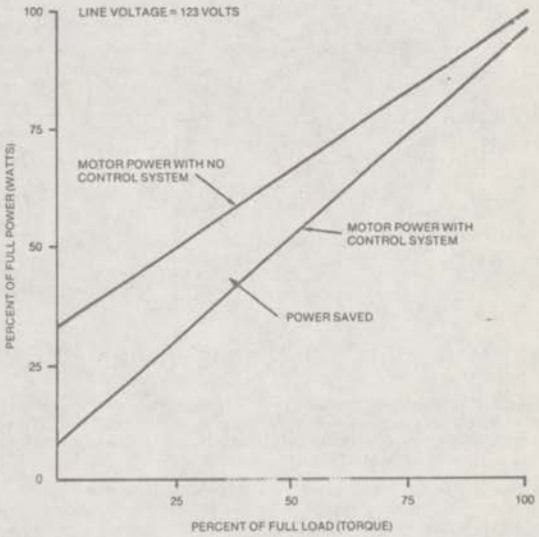


Figure 1. **Power Saved** is shown as averaged from tests made on a 1/3-hp split-phase motor and 1/4- and 3/4-hp capacitor-start motors. The top curve is the total power taken as a function of load with no control system. The bottom curve represents the total power with the voltage controlled by the circuit in Figure 2. Curves are plotted as percent of full power versus percent of full load. The circuit reduced the no-load power by a factor of 5 or 6 and increased the power factor from 0.2 to 0.8. In all three motors, the slowdown due to reducing the applied voltage was less than 2 percent.

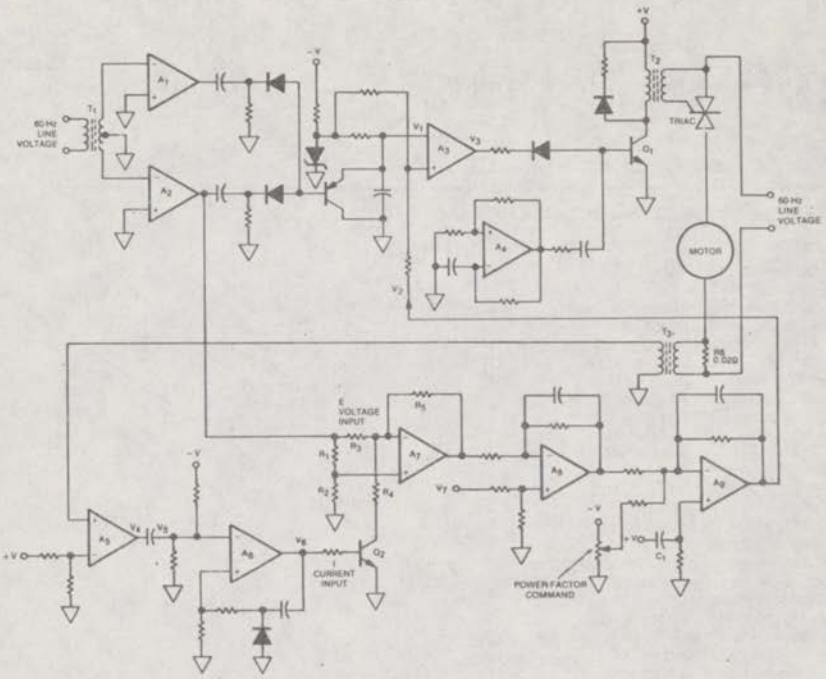


Figure 2. The **Electronic Control Circuit** consists of a typical phase-control circuit (top half) and a new circuit that senses the voltage/current phase lag in an ac inductor motor. This phase lag is used to produce an error signal (V_2) for the phase-control circuit, where a control pulse is developed to switch a Triac that regulates the motor voltage in response to loads.

The phase lag between the voltage and current in the motor is sensed and is used to produce a dc voltage proportional to phase lag. This signal is fed back and summed with a power factor command signal. The difference between these two voltages is an error signal (V_2) that drives amplifier A_3 and controls the voltage to the motor.

This work was done by Frank J. Nola of **Marshall Space Flight Center.** *For further information,* Circle 3 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning license for its commercial development should be addressed to the Patent Counsel, Marshall Space Flight Center [see page A8]. Refer to MFS-23280.

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United States Patent [19]

Nola

[11] **4,052,648**

[45] **Oct. 4, 1977**

[54] **POWER FACTOR CONTROL SYSTEM FOR AC INDUCTION MOTORS**

[75] Inventor: **Frank J. Nola**, Huntsville, Ala.

[73] Assignee: **The United States of America as represented by the Administrator of the National Aeronautics and Space Administration**, Washington, D.C.

[21] Appl. No.: **706,425**

[22] Filed: **July 19, 1976**

[51] Int. Cl.² **H02K 17/04**

[52] U.S. Cl. **318/200**; 318/227; 318/230

[58] Field of Search ..... 318/200, 227, 230, 231, 318/221 R, 216

[56] **References Cited**

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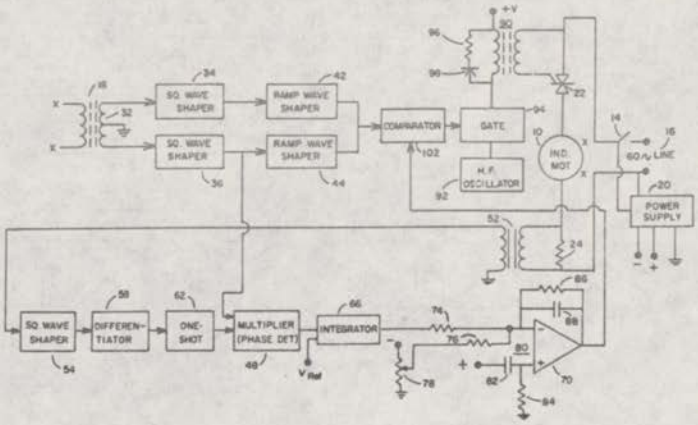
Primary Examiner—Herman J. Hohauser

Attorney, Agent, or Firm—L. D. Wofford, Jr.; George J. Porter; J. R. Manning

[57] **ABSTRACT**

A power factor control system for use with AC induction motors which samples line voltage and current through the motor and decreases power input to the motor proportional to the detected phase displacement between current and voltage to thereby provide less power to the motor, as it is less loaded.

5 Claims, 3 Drawing Figures



AMD (CC 1-3) 2 3

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NEW TECHNOLOGY TRANSMITTAL
(See Instructions on Reverse)

Approved Through January 1970
Bodget Bureau No. 104-R0046

NT CONTROL NUMBER (CC 4-11): M F S - 2 3 2 8 0

1. TITLE
Power Factor Control System for Improved Efficiency in an AC Induction Motor

2. INNOVATOR(S) (Name and Social Security No.)
Frank J. Nola

3. EMPLOYER (Organization and division)
NASA-MSFC
EC24

4. ADDRESS (Place of performance)
Marshall Space Flight Center, AL

5. DOCUMENTATION (Full and complete disclosure, must be enclosed, the contents of which are discussed in NHB 2170.3, Documentation Guidelines for New Technology Reporting. Place an "X" to the left of those items of documentation which are available but NOT enclosed with this transmittal)

	ENGINEERING SPECIFICATIONS		OPERATING MANUALS		COMPUTER TAPES/CARDS
	ASSEMBLY/MFG DRAWINGS		TEST DATA		
	PARTS OR INGREDIENTS LIST		ASSEMBLY/MFG PROCEDURES		

6. PREVIOUS PUBLICATION OR PUBLIC DISCLOSURE

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BY: ☐ NASA ☐ OTHER GOVT. ☐ CONTRACTOR ☐
VOLUME NO. | PAGE | DATE | STATUTORY BAR ESTABLISHED (Date)
TITLE

PATENT
STATUS: ☐ APPLICATION FILED ☐ ISSUED | NO. | DATE

7. STATE OF DEVELOPMENT
☐ CONCEPT ONLY ☐ DESIGN ☐ PROTOTYPE ☐ MODIFICATION ☐ PRODUCTION MODEL ☐ USED IN CURRENT WORK

8. ORIGIN (CC 12) N (12)
9. NASA PRIME CONTRACT NO. (CC 13-23) (13 14 15 16 17 - 18 19 20 21 22 23)
10. SUBCONTRACT TIER (CC 24) (24)
11. CONTRACTOR REPORTABLE ITEM NO. (CC 25-33) (25 26 27 28 29 30 31 32 33)
12. CONTRACTOR/GRANTEE NEW TECHNOLOGY NOT SUBMITTED PURSUANT TO NT/PRI CLAUSE PROVISION (CC 34) ☐

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14. NT RI
NT DATE (CC 42-47): MO 0 6 | DAY 1 6 | YR 7 5 (42 43 44 45 46 47)
15. PROJ. NO. (CC 48-51) (48 49 50 51)
16. EVALUATION ORGANIZATION (CC 52-54): I L T (52 53 54)
T FORWARDED FOR VALUATION (Date) (CC 55-60): MO 6 6 | DAY 3 0 | YR 7 5 (55 56 57 58 59 60)
18. COMMENTS

	NAME AND TITLE	SIGNATURE	DATE
19. PREPARED BY			
20. APPROVED (Center TUO)	NAME	SIGNATURE HLM	DATE 6/30/75

NASA FORM 666 SEP 68 PREVIOUS EDITIONS ARE OBSOLETE.

U.S. Patent Oct. 4, 1977 Sheet 1 of 3 4,052,648

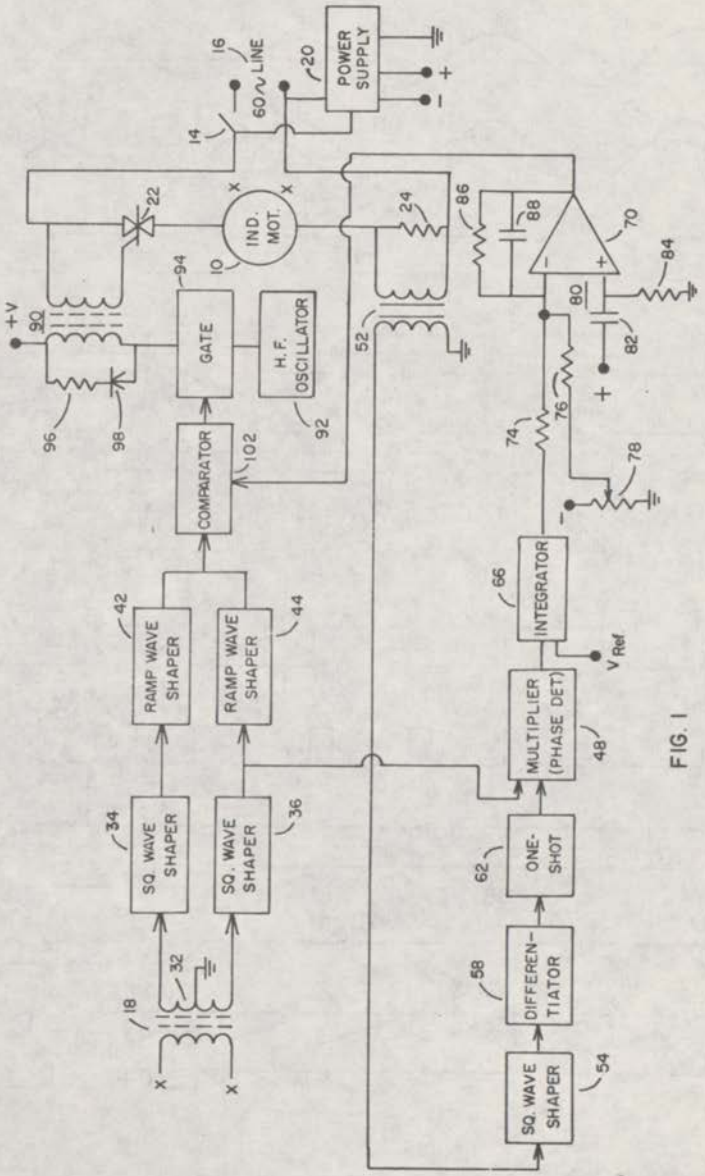


FIG. 1

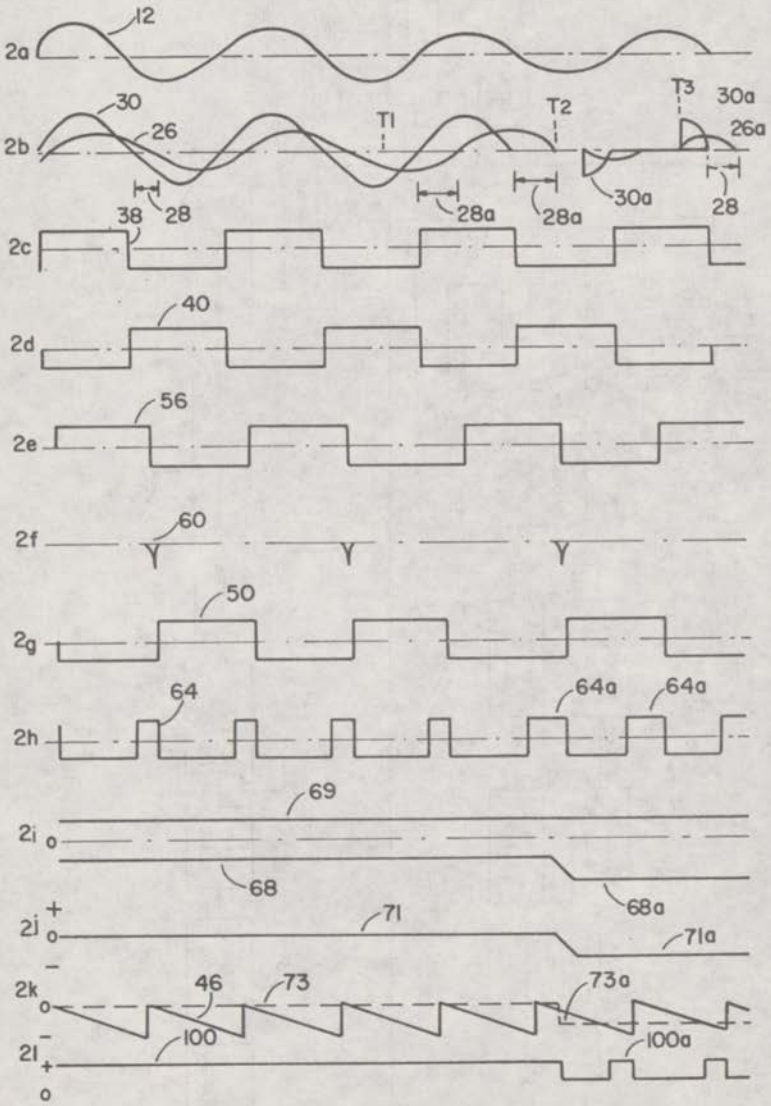

2a
12
2b
30
26
T1
T2
T3
30a
26a
28
28a
28a
30a
28
2c
38
2d
40
2e
56
2f
60
2g
50
2h
64
64a
64a
2i
69
68
68a
2j
71
71a
2k
46
73
73a
2l
100
100a

FIG. 2

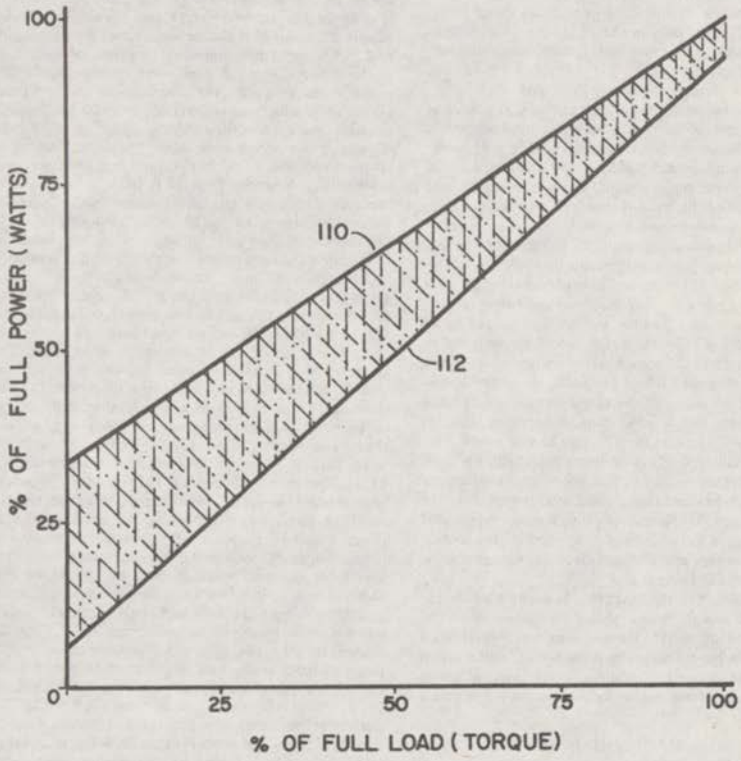

100
75
50
25
0
% OF FULL POWER (WATTS)
110
112
25
50
75
100
% OF FULL LOAD (TORQUE)

FIG. 3

POWER FACTOR CONTROL SYSTEM FOR AC INDUCTION MOTORS

ORIGIN OF THE INVENTION

The invention described herein was made by an employee of the United States Government, and may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to power input controls for motors, and particularly to a control which varies input power to an AC induction motor proportional to loading on the motor.

2. General Description of the Prior Art

The induction motor is perhaps the most rugged, and is certainly one of the most commonly used motors. It runs at an essentially constant speed which, within certain limits, is independent of both load and applied voltage. For efficient operation, the applied voltage should be a function of the load. Heretofore, this has not been practically accomplished. Line voltages are a matter of availability from a local utility. In the case of nominal **115-volt** service, line voltage may be typically in the range of 105 to 125 volts and may not be constant with the service from a particular source and often varying significantly over a 24-hour period. In recognition of this, typically a 115-volt motor would be designed to deliver its rated load plus a safety margin at an under voltage condition of 105 to 110 volts. However, in taking care of the ability of the motor to perform its rated job at under voltage conditions, it becomes wasteful when line voltage is in the 120- to 125-volt range. Further, since this type of motor draws essentially the same current whether loaded or unloaded, motor efficiency goes down when less than a rated load is applied to the motor. Thus, where a user employs a motor over-rated for a job or a variable load is applied to the motor, efficiency suffers and waste of electrical power occurs.

3. Object of the Invention

It is the object of this invention to provide an electrical device which, when placed in circuit with the power input of an AC induction motor, will effect a reduction in power normally provided the motor when operated in either a condition where line voltage is greater than normal and/or motor loading is less than a rated load.

SUMMARY OF THE INVENTION

In accordance with the invention, the voltage applied to an AC induction motor and current through that motor are sampled, the phases of the samples are compared, and a control signal representative of the difference is obtained. This signal is then employed to vary the duty cycle portion of each cycle (portion of each cycle of alternating current) applied to the motor, decreasing the duty cycle proportional to phase difference to thereby regulate phase difference and thus improve the power factor to a more optimum state when there is otherwise present less than an optimum relationship between line voltage and motor load.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an electrical schematic diagram of an embodiment of the invention.

FIGS. **2***a*–*2l* are waveforms illustrating aspects of operation of the invention.

FIG. **3** is a plot illustrating power drawn by a motor for different states of loading and with and without the control system of this invention.

DETAILED DESCRIPTION OF THE DRAWINGS

An AC induction motor **10** is powered by an alternating current voltage **12** (FIG. **2***a*) through switch **14** and connectible at terminals **16**. The switched AC power is also applied to transformer **18** and circuit bias power supply **20**. Triac **22** is connected in series with motor **10** and is triggered for controlled portions of each half cycle of power input. A small value resistor **24** of 0.010 to 0.020 ohms is connected in series with motor **10** and serves to develop a signal **26** (FIG. **2***b*) which is proportional to the current flow through the motor. FIG. **2***b* illustrates an instantaneous state of operation after initial start-up and with an initial optimum input voltage-load relationship, whereby triac **22** is fully on and where, thereafter, loading is substantially decreased. The initial current-voltage phase lag **28** for such optimum state of operation may vary from motor to motor and would be determined for each motor with which this invention is to be employed. In the present example, initially, optimum phase lag **28** is approximately 30°, and potentiometer **78** is adjusted to provide the zero error output signal for the control of the turn on time of triac **22** to maintain the phase angle of this or another selected value. The occurrence of increased current lag **28***a* at time T_1 depicts a sudden decrease in loading of motor **10**. The detection of this is used, as will be further explained, to reduce the average amplitude of input voltage and thereby to effect a commanded, optimum, phase lag.

To further examine the circuitry, transformer **18**, having center tap secondary **32**, provides oppositely phased inputs to square wave shapers **34** and **36**, and the resulting oppositely phased outputs, square wave **38** (from shaper **36**) shown in FIG. **2***c* and square wave **40** (from shaper **34**) shown in FIG. **2***d*, which are fed to saw tooth or ramp wave shapers **42** and **44**, respectively. The outputs of the wave shapers are combined to provide a ramp wave each half cycle of the alternating current input as shown in waveform **46** of FIG. **2***k*. Waveform **38** is also used as a reference signal for the phase of input voltage and is fed to one input of multiplier **48**, functioning as a phase detector, to which is also fed a current reference signal **50** shown in FIG. **2***g*. The current reference signal is generated as follows. Current signal **26** (FIG. **2***b*) from resistor **24** is fed to isolation transformer **52** and from it to square wave pulse shaper **54**, which provides square wave **56** (FIG. **2***e*). This square wave is differentiated in differentiator **58** to provide spike pulses **60** shown in FIG. **2***f*, and the negative pulses (derived from the trailing edge of square wave **56**) are used to trigger one-shot **62**, which provides as an output the square waveform **50** shown in FIG. **2***g*. This square waveform commences at a time corresponding to the trailing or zero crossing point of current signal **26** (FIG. **2***b*) and has a duration (determined by the time constant of one-shot **26**) corresponding to the length of a half cycle of AC input to the motor. Thus, there is generated a square wave current signal which is of the

same duration as a half wave of voltage waveforms **12**, **38**, and **40**, which is shifted in position proportional to the phase shift difference between current and voltage by virtue of the square wave current responsive signal being commenced at the precise end of (zero crossing) a half cycle of the current signal, which ending in time thus varies as a function of current lag.

Multiplier **48** multiplies voltage waveform **38** as shown in FIG. **2***e* with current waveform **50** shown in FIG. **2***g* to provide the product output waveform **64** shown in FIG. **2***h*. This output is integrated and reversed in sense in integrator **66**. Except for this reversal, the output of integrator **66** would be maximum for conditions of no current lag and minimum for large current lags. To achieve the opposite sense, a reference voltage V_f is fed to one input of integrator **66** where it is negatively summed with the output of multiplier **48**. As a result, the integrated output of integrator **66** is of a value **68**, shown in FIGS. **2***i* and **2***j*, which varies in magnitude directly with phase angle. In other words, the greater the phase angle the greater the system error which is to be corrected. Output **68** (output **68***a* after time T_2) of integrator **66**, which is proportional to the phase angle, is fed to the negative input of operational amplifier **70**. To this same input is also applied an opposite polarity phase angle command voltage **69** (FIG. **2***i*), being applied through resistor **76** from potentiometer **78**. Potentiometer **78** is calibrated to provide an output voltage representative of a desired phase angle to be commanded. Thus, when the system is operating with a commanded phase angle, the output of integrator **66** would be equal and opposite to the command signal from potentiometer **78**, a condition shown by FIG. **2***j* as existing up to time T_3. At this point, by virtue of increased output **64***a* from multiplier **48** because of increase phase shift **28**, the output of integrator **66** increases negatively to a level **68***a*. Thus, there would initially be a net zero error voltage input **71** (FIG. **2***f*) to the negative input terminal of amplifier **70**. Then, for the indicated phase lag in excess of the commanded phase lag, there would be a finite negative error signal **71***a* applied to this input, as shown. When this occurs, amplifier **70**, which is a high gain amplifier, provides an amplified error signal **73***a* (FIG. **2***k*) to comparator **102** to effect such decrease in duty cycle of triac **22** necessary to retain the commanded, optimum, phase angle, in a manner to be described. As shown, this is effected during any interim between times T_2 and T_3.

In order to assure that when motor **10** is first turned on that it will develop maximum torque for a sufficient period to bring the motor up to speed, operation of the control system of this invention is initially delayed. This delay is achieved by delay circuit **80** consisting of capacitor **82** and resistor **84** connected in series between a bias output of power supply **20**, which power supply is energized at the same time as motor **10**, that is, by the closing of switch **14**. Resistor **84** is connected between common ground and the positive input of operational amplifier **70**. With a positive potential signal applied to capacitor **82**, the initial charging current through resistor **84** is of a value sufficient (determined by the time constant of the combination of resistor **84** and capacitor **82**) to override a maximum input applied to the negative terminal for a period of several seconds or longer, depending upon the application. A feedback circuit consisting of resistor **86** and capacitor **88**, connected in parallel between the output of amplifier **70** and the negative input of the amplifier, provides the necessary gain and roll off frequency required for system stability.

Triac **22** is gated "on" by a gating signal coupled from the secondary of transformer **90** across an input of triac **22**. This gating signal is a high frequency signal generated by oscillator **92** and applied to the primary of transformer **90** through gate or electronic switch **94**. Resistor **96** and diode **98** are connected in series across the primary of transformer **90** in order to suppress inductive voltages to a safe level consistent with the semiconductors used. Gate **94** is triggered by pulses **100** (shown in FIG. **2***l*, and which illustrates "on" time of oscillator **92**) from comparator **102** responsive to ramp waveform **46** (FIG. **2***k*) and control input signal **73** (FIG. **2***k*). Output pulses **100** from comparator **102** occur during the interval in which control signal **73** exceeds (is more positive than) ramp voltage **46**. Thus, in the present example, the output of amplifier **70** initially provides a maximum (in a positive direction) output, and pulses **100** would have a 100 percent duty cycle extending over a full ramp period. This would gate "on" oscillator **92** and thereby triac **22** for the entire portion of input voltage cycle as initially shown for voltage waveform **30** in FIG. **2***b*. This, it will be assumed, continues for several seconds and until time T_1, at which time the motor loading decreases to near zero. When this occurs, phase lag **28** will increase to some larger value of phase leg **28***a*, and this will increase, resulting in a shift to the right of current pulse waveform **50** (FIG. **2***g*), which in turn will provide an increased width output pulse **64** from multiplier **48** (at time T_2). In turn, this will provide an increase in the output of integrator **66** and input to amplifier **70**, which will change from a zero level (level **71**) to a discrete negative level (level **71***a*), as shown in FIG. **2***j*. As a result, amplifier **70** will provide an amplified, less positive, output error signal **73***a* commencing at time T_2, as shown in FIG. **2***k*. When this occurs, comparator **102** provides a reduced width pulse **100***a* to gate **94**, and it triggers "on" triac **22** for like decreased width periods to produce a change in input voltage, changing (at time T_3) from that shown by waveform **30** to that shown by waveform **30***a*.

Thus, motor input voltage waveform **30** goes through a transition during the period of T_1 to T_3, having an initial phase lag **28** to an increased phase lag **28***a* and then back to the commanded phase lag **28**, shifting from full width cycles **30** to extremely short width duration input cycles **30***a*. The shift in input voltage has been that necessary to re-establish the commanded currentvoltage phase lag, power factor, to thus maintain an optimum power input to motor **10**. Had this not been done, the phase angle would have increased substantially, and thus the power factor would have decreased substantially, resulting in a significant waste of power.

FIG. **3** plots the percent of full power applied to motor **10** versus percent of full load, or torque, and line **112** illustrates a case where the control system of this invention is employed. Line **110** illustrates a case where it is not. The hatched difference between the lines is indicative of the power saved by employment of the invention.

While the invention illustrated herein is shown as being usable with a single phase device, it may be connected in circuit with each phase of a multi-stage induction motor. Thus, in the case of a Wye-connected three phase motor, three of the control systems illustrated in FIG. **1** will be employed, one being connected in each of the three phases with each referenced to ground (the

Wye of the motor). In the case of a delta-connected motor, it will be necessary to place a triac and sampling resistor in series with each winding of the motor, and the voltage reference would be obtained for that control device across the two input power leads to that winding.

Having thus described my invention, what is claimed is:

1. A power factor control system for an AC induction motor comprising:

current sampling means including means adapted to be placed in circuit with each phase winding of a said motor for providing an AC output signal in phase with the current through said winding;

voltage sampling means adapted to sense the voltage of an electrical input applied to said winding and for providing an output signal in phase with said voltage across said winding;

phase detection means responsive to the outputs of said current sampling means and said voltage sampling means for providing an output which varies in accordance with the difference in phase between said current and said voltage; and

a control means adapted to be electrically connected in series with each said winding of said motor, and responsive to the output of said phase detection means for varying the duration of "on" time of each cycle of input power to said winding inversely proportional to the difference in phase between said current and said voltage;

whereby an increase in difference between the magnitude of said voltage and the magnitude of load applied to said motor is compensated for by a reduction in power to said motor, generally improving its efficiency.

2. A control system as set forth in claim 1 wherein said current sampling means includes a resistor adapter to be placed in series with a said winding and means for providing a signal proportional to the voltage across said resistor.

3. A control system as set forth in claim 2 wherein:

said voltage sampling means comprises means for providing a square wave pulse output at the frequency of the voltage applied to said winding; and

said current sampling means comprising means responsive to said voltage from said resistor for providing square wave output pulses of the width and height of said pulses from said voltage sampling means, and each pulse having an edge coinciding with the zero crossing of said voltage across said resistor.

4. A control system as set forth in claim 3 wherein said phase detection means includes means for multiplying the magnitudes of said square wave pulses from said voltage and current sampling means.

5. A control system as set forth in claim 4 wherein said control means includes:

means responsive to the voltage applied to said winding of said induction motor for providing a saw tooth wave at double the frequency of said voltage;

pulse generating means responsive to a comparison of said saw tooth voltage and said output of said phase detection means for providing output pulse bursts of high frequency signal in which the width of the pulse bursts is directly proportional to the time in which said output of said phase detection means differs in a selected direction from the value of said saw tooth wave; and

switching means adapted to be placed in circuit with said winding of said motor and responsive to said pulse generating means for varying the width of half cycles of power applied to said winding of said motor in accordance with the width of said bursts of high frequency signal.

* * * * *

ORGANIZATION:	MARSHALL SPACE FLIGHT CENTER	NAME:
ELECTRONICS AND CONTROL LABORATORY	POWER FACTOR CONTROLLER	FRANK NOLA
		DATE: JUNE 1978

BACKGROUND

- ORGANIZATION

  GUIDANCE, CONTROL AND INSTRUMENTATION DIVISION
  ELECTRONICS AND SERVO ANALYSIS BRANCH

- BECAME INVOLVED THROUGH MSFC'S SOLAR HEATING AND COOLING PROGRAM
- INITIAL WORK DONE IN APRIL 1975
- NOTIFIED IN MAY 1977 PATENT WOULD BE ISSUED
- CONCEPT VERIFIED BY AUBURN UNIVERSITY
- PATENT ISSUED OCTOBER 1977

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		DATE: JUNE 1978

ENERGY IN MOTORS

- STUDY BY A.D. LITTLE CORP. INDICATES ABOUT TWO THIRDS OF ELECTRICAL ENERGY GENERATED IS FOR MOTORS.
- THIS AMOUNTS TO ABOUT 1100 BILLION KWHR PER YEAR
- 10 PERCENT IS IN HOMES AND 90 PERCENT IN INDUSTRY
- REQUIRES THE EQUIVALENT OF 6,000,000 BARRELS OF OIL PER DAY
- EACH PERCENT ENERGY TO MOTORS IS REDUCED SAVES THE EQUIVALENT OF 60,000 BARRELS OF OIL PER DAY

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FILE NO.

43-843 O - 79 - 5

ORGANIZATION:	MARSHALL SPACE FLIGHT CENTER	NAME:
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INDUCTION MOTORS

- DESIGNED FOR CONSTANT VOLTAGE AND CONSTANT FREQUENCY
- RUN AT ESSENTIALLY CONSTANT SPEED REGARDLESS OF LOAD
- CURRENT REMAINS HIGH AT NO LOAD CREATING LARGE INTERNAL LOSSES
- NO LOAD CURRENT IN SINGLE PHASE MOTORS IS 70 TO 90% OF RATED LOAD CURRENT
- NO LOAD CURRENT IN 3 PHASE MOTORS IS 50 TO 60% OF RATED LOAD CURRENT
- PHASE ANGLE BETWEEN VOLTAGE AND CURRENT INCREASES WITH DECREASING LOAD

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FILE NO. _____

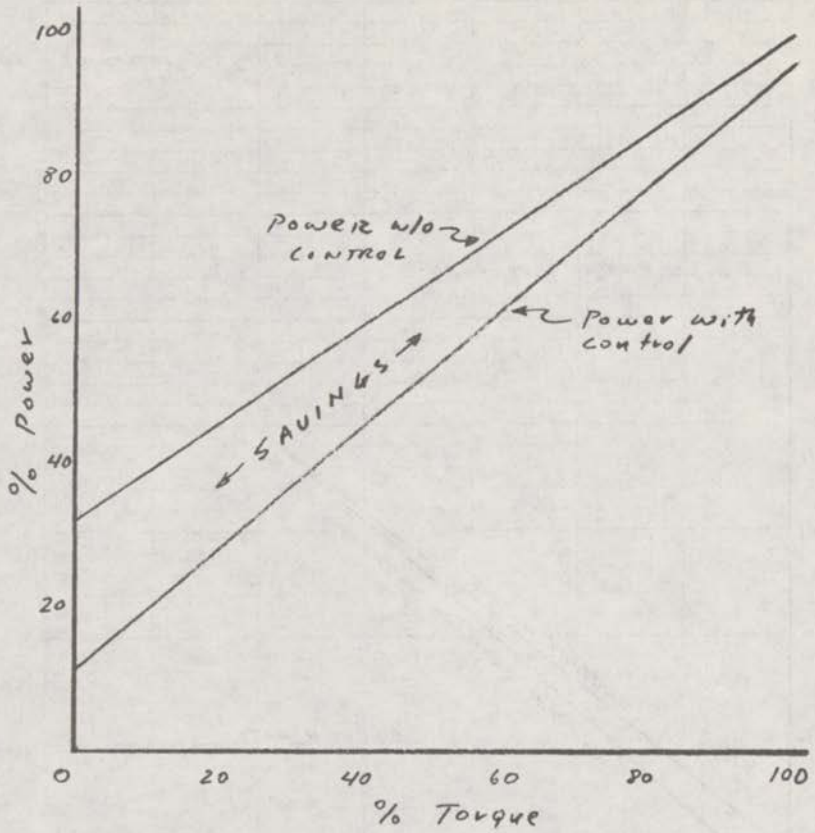
ORGANIZATION:	MARSHALL SPACE FLIGHT CENTER	NAME:
ELECTRONICS AND CONTROL LABORATORY	POWER FACTOR CONTROLLER	FRANK NOLA
		DATE: JUNE 1978

CONCEPT

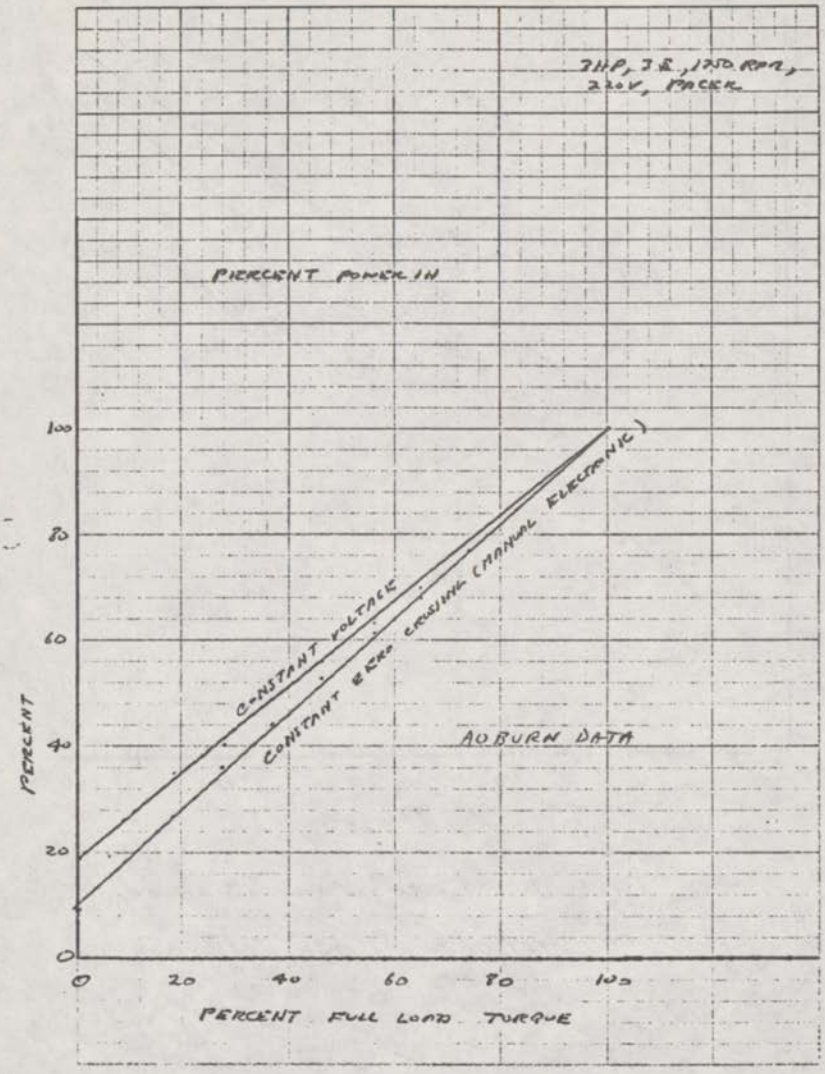
- THE DEVICE SENSES THE LINE VOLTAGE AND LINE CURRENT
- PRODUCES A VOLTAGE PROPORTIONAL (INVERSELY) TO PHASE ANGLE BETWEEN VOLTAGE AND CURRENT.
- COMPARES THIS VOLTAGE WITH A COMMANDED REFERENCE VOLTAGE INDICATIVE OF A DESIRED PHASE ANGLE.
- DIFFERENCE IS AN ERROR VOLTAGE WHICH BIASES A RAMP THAT IS IN SYNC WITH THE 60 HZ LINE VOLTAGE
- RAMP AND ERROR ARE COMPARED IN A ZERO CROSSING DETECTOR. (ZCD)
- THE OUTPUT OF THE ZCD FORMS THE FIRING PULSE FOR TURNING ON A TRIAC IN SERIES WITH THE MOTOR.
- NO MODIFICATION REQUIRED FOR SINGLE PHASE MOTORS
- WYE CONNECTED MOTORS REQUIRE CONNECTION TO WYE POINT

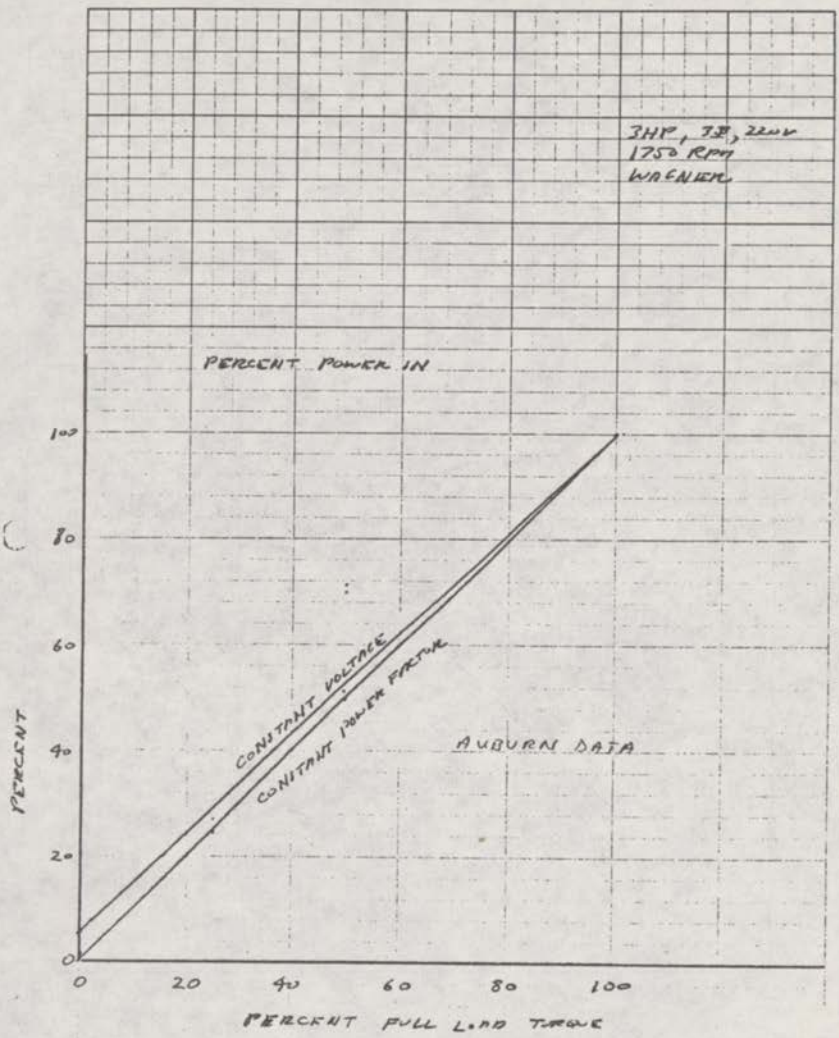
MSFC - Form 3204 (Rev October 1972)

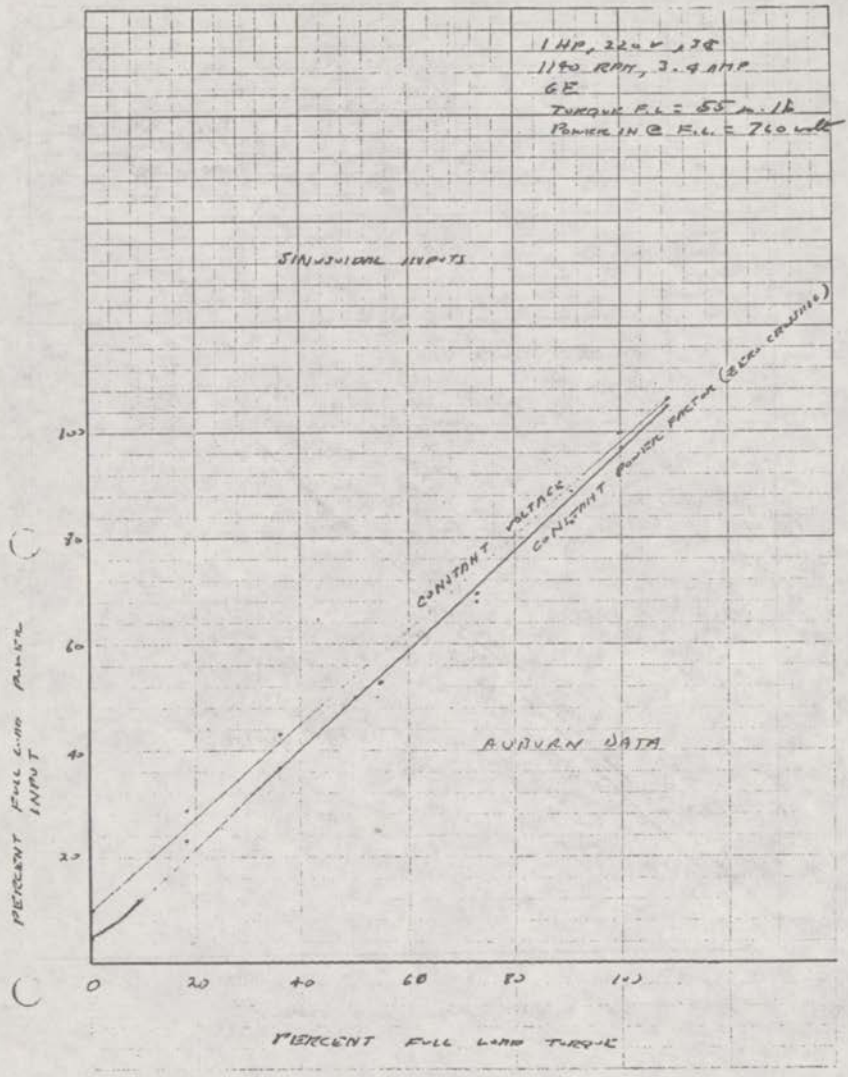
FILE NO. _____

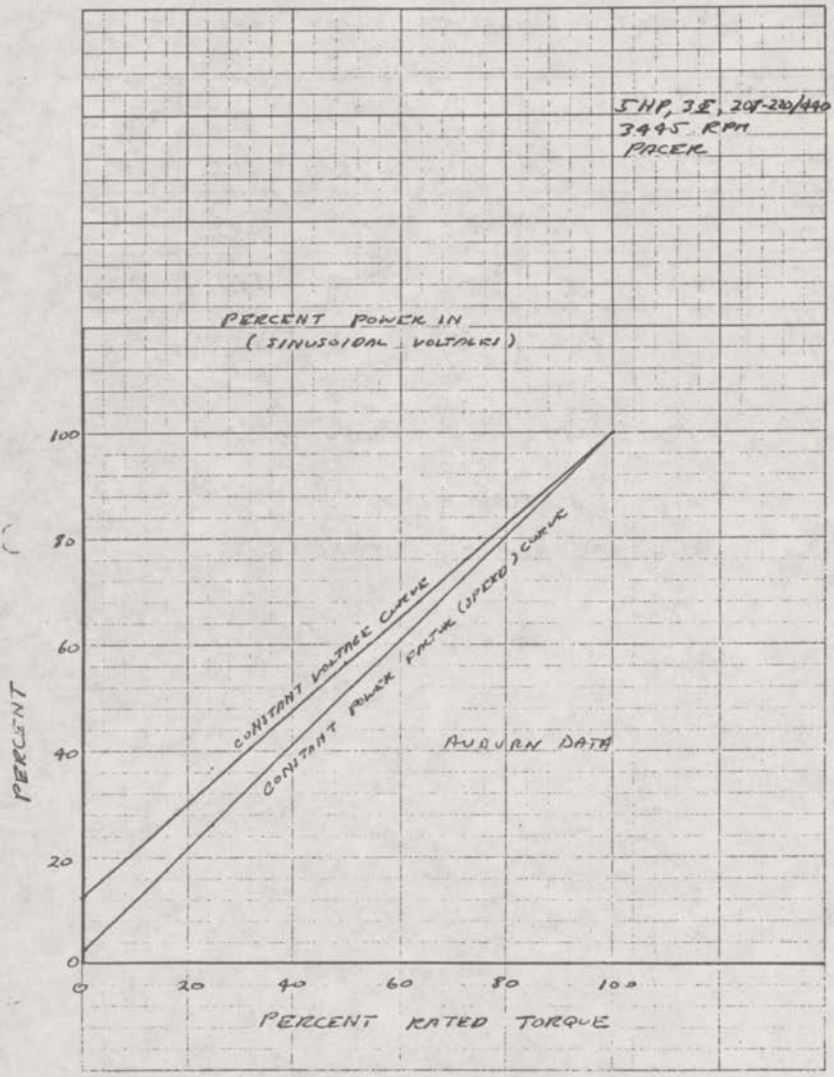


TYPICAL POWER SAVINGS FOR SINGLE PHASE MOTOR


7½P, 3Ø, 1750 RPM, 220V, FACTR.
PERCENT POWER IN
CONSTANT VOLTAGE
CONSTANT ZERO CROSSING (MANUAL ELECTRONIC)
AUBURN DATA
PERCENT
0
20
40
60
80
100
PERCENT FULL LOAD TORQUE


3HP, 7B, 220V
1750 RPM
WAGNER
PERCENT POWER IN
100
80
60
40
20
0
PERCENT
CONSTANT VOLTAGE
CONSTANT POWER FACTOR
AUBURN DATA
0
20
40
60
80
100
PERCENT FULL LOAD TORQUE


1 HP, 220 V, 1Ø
1140 RPM, 3.4 AMP
GE
TORQUE F.L. = 55 in. lb
POWER IN @ F.L. = 760 watt
SINUSOIDAL INPUTS
CONSTANT VOLTAGE
CONSTANT POWER FACTOR (ECM CONTROL)
AVAILABLE DATA
PERCENT FULL LOAD POWER INPUT
PERCENT FULL LOAD TORQUE
0
20
40
60
80
100


5 HP, 3E, 208-230/460
3445 RPM
PACER
PERCENT POWER IN
(SINUSOIDAL VOLTAGE)
100
80
60
40
20
0
PERCENT
CONSTANT VOLTAGE CURVE
CONSTANT POWER FACTOR (SPEED) CURVE
AUBURN PATH
0
20
40
60
80
100
PERCENT RATED TORQUE

PERCENT SAVINGS AT VARIOUS LOADS

LOAD → CONDITION	FULL LOAD	80%	60%	40%	20%	NO LOAD
3 HP WAGNER	0%	1.5%	4%	7%	15%	60%
5 HP PACER	0%	4%	8%	15%	30%	65%
1 HP GE	1.5%	4%	7%	10%	25%	50%
3 HP PACER	0%	2.5%	6%	10%	20%	50%

TABULATED FROM AUBURN DATA

ALL 3 ϕ MOTORS

MANUAL PHASE CONTROL

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		DATE: JUNE 1978

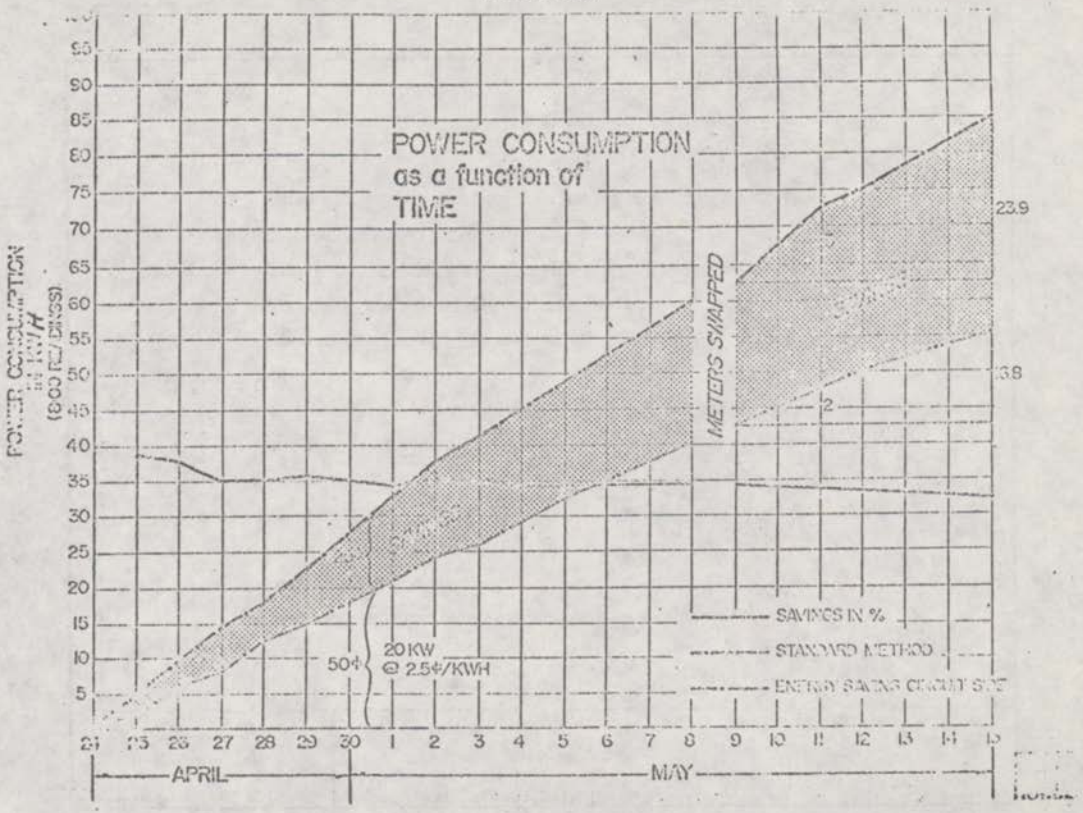
TEXTILE MILL APPLICATION

- BREADBOARD CONTROLLER WHICH WAS GOVERMENT FURNISHED TO AUBURN WAS TESTED IN A TEXTILE MILL.
- MILL HAS 3700 SEWING MACHINES
- EACH MACHINE HAS A 1/2 HP AMCO 3-PHASE MOTOR WITH WYE CONNECTION EXTERNAL TO MOTOR FOR CONNECTING TO LIGHT.
- PLANT RESEARCH ENGINEER INDICATED THIS IS AN INDUSTRY STANDARD MOTOR SELECTED FOR HIGH PERFORMANCE AND RELIABILITY AND ESTIMATES 90% USEAGE IN TEXTILE INDUSTRY. COST $80 WITH CLUTCH.
- CONTROLLER WAS CONNECTED TO ONE MACHINE. THIS MACHINE AND A SECOND MACHINE WERE INSTRUMENTED FOR MEASURING POWER CONSUMPTION.
- A TYPICAL 20 DUTY CYCLE WAS SIMULATED FOR BOTH MACHINES.
- BOTH MACHINES RAN 24 HRS A DAY FOR 21 DAYS
- MACHINE EQUIPPED WITH CONTROLLER INDICATED ABOUT 33% LESS POWER CONSUMPTION

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FILE NO. _____

FIGURE NO. 3


POWER CONSUMPTION
as a function of
TIME
POWER CONSUMPTION
METERS SWAPPED
23.9
13.8
SAVINGS IN %
STANDARD METHOD
50¢
20 KW
@ 2.5¢/KWH
APRIL
MAY

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		DATE: JUNE 1978

TO BE DETERMINED

- POTENTIAL THIS CIRCUIT HAS FOR SAVING ENERGY
- COST TO PRODUCE THE DEVICE - BOTH SINGLE AND 3 PHASE
- COST EFFECTIVENESS OF APPLYING THE DEVICE
- CAN THE DEVICE AID IN CUTTING COSTS CHARGED FOR A POOR POWER FACTOR? CAN IT REPLACE CAPACITORS AND SYNCHRONOUS MOTORS USED FOR CORRECTION.
- IN CERTAIN APPLICATIONS CAN THE DEVICE DOUBLE AS THE POWER CONTACTOR FOR THE MOTOR?
- CAN THE DEVICE SERVE AS A MEANS OF LIMITING STARTING INRUSH CURRENT IN LARGE MOTORS?
- POTENTIAL FOR REDUCING AIR CONDITIONING COSTS.
- HOW SERIOUS IS THE PROBLEM OF CONNECTING TO THE WYE POINT OF 3 PHASE WYE MOTOR?
- IS THE WYE POINT AVAILABLE IN LARGER MOTORS?
- EFFECT ON UTILITIES DISTRIBUTION SYSTEM
- IS THE SAVINGS TO THE UTILITY COMPANY SIGNIFICANT?
- STABILITY NEEDS TO BE ANALYZED
- ABILITY TO RESPOND TO STEP TYPE LOADING NEEDS TO BE STUDIED AND IMPROVED
- IN SOME CASES THE CAPACITOR REQUIRED FOR STABILITY NEEDS TO BE LARGER THAN THAT REQUIRED FOR FILTERING. THIS SLOWS THE RESPONSE.

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		DATE: JUNE 1978

TO BE DETERMINED (CONT'D)

- IN SOME CASES THERE HAS BEEN A MISFIRING OF THE TRIAC
- BALANCING OF THE 3 ERROR SIGNALS IN 3 PHASE MOTORS MAY BE A PROBLEM
- POSSIBILITY OF ELIMINATING THE NEED FOR CONNECTING TO THE WYE POINT NEEDS INVESTIGATING

MSFC - Form 3004 (Rev October 1972)

FILE NO. _____

The patent is somewhat difficult to read and the circuitry it describes, we have since learned, is more complex than required.

Following is a simpler explanation and a circuit we believe is better.

The reactive volt amps of an induction motor is high when the motor is unloaded or partially loaded. Six single phase motors we tested showed unloaded current to be about 90% of the rated load current. Four three-phase motors (5 Hp down) showed the no load current to be about 50 to 60% of rated load current. These currents cause heat losses in the motor and in the utilities distribution system. Large users of motors with cyclic loads are often charged for a poor power factor.

Since the current remains high in an unloaded motor, the phase angle between voltage and current shifts with load. Typically the current may lag the voltage 80° in an unloaded motor and 30° when loaded. The power factor control circuit continuously monitors the phase angle between the voltage and current and produces a voltage proportional to the phase angle. This voltage is summed with a fixed reference voltage which is indicative of a desired phase angle. The difference of the two produces an error signal which biases a ramp voltage that is in sync with the 60 Hz line voltage. The intersection of the ramp and the error voltages are detected by a squaring amplifier whose output provides the timing for turning on a triac (or SCR's) in the motor line.

Thus the "on" time of the triac varies with the load and varies the voltage to force the phase angle to remain at the commanded value.

With the system in control, typical motor voltage and current waveforms are as shown in the attached timing diagram.

The phase angle shown as θ in the timing diagram is measured by detecting the time between the zero crossings of the voltage and the zero value of the trailing edge of the current.

In the circuit, amplifiers A1 and A2 produce a square wave and its inverse which are in sync with the zero crossings of the voltage.
These are E and $\bar{E}$ in the timing diagram.

The current waveform which is sensed by the resistor (R20) transformer (T3) combination or by a current transformer is squared by amplifiers A5 and A6 to produce I and I'. $\bar{E}$ is AND'ed with I and E is AND'ed with I'. These two outputs are OR'ed to produce the voltage which is representative of the phase angle between voltage and current.

This voltage is filtered and summed with the command voltage in ampliffer A7. The output is the system error signal and is compared with the ramp voltage in Amplifier A3. The error is shown superimposed on the

ramp in the timing diagram. The intersection of the error voltage and the sloped portion of the ramp form the turn on time for the triac. The triac remains on until the current passes through zero for each half cycle. C7 and R27 are a starting override that commands full voltage for starting the motor.

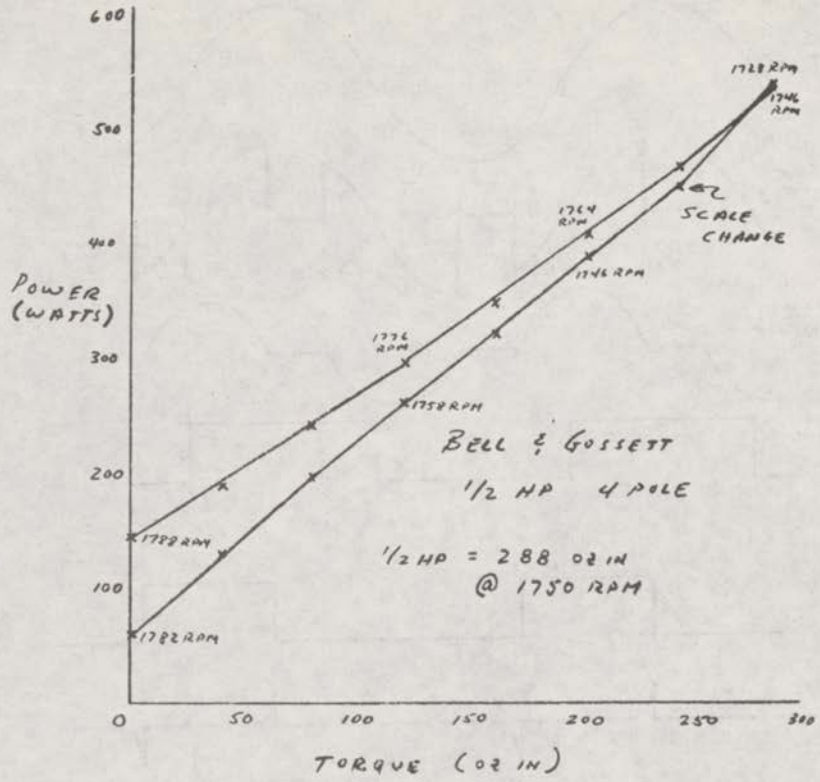
The circuit described by the patent and shown in the tech brief functions in a similar manner. The current waveform is squared only once as shown by I in the timing diagram. The falling edge of the squared pulse contains the phase angle information. This waveform is differentiated to form trigger pulses which are fed to a one shot. The one shot is sensitive only to the negative trigger (falling edge) and the transition time is set to be equal to a half cycle of 60 Hz. Thus a symmetrical square wave is produced which contains the phase shift information. This square wave is fed to one input of a multiplier. The line voltage is squared and fed to the second input. The output of the multiplier is similar to the ORed voltage shown in the timing diagram. The remainder of the circuit functions identical to that previously described. Amplifier A8 shown in the tech brief and called integrator (66) in the patent is not required and has been eliminated.

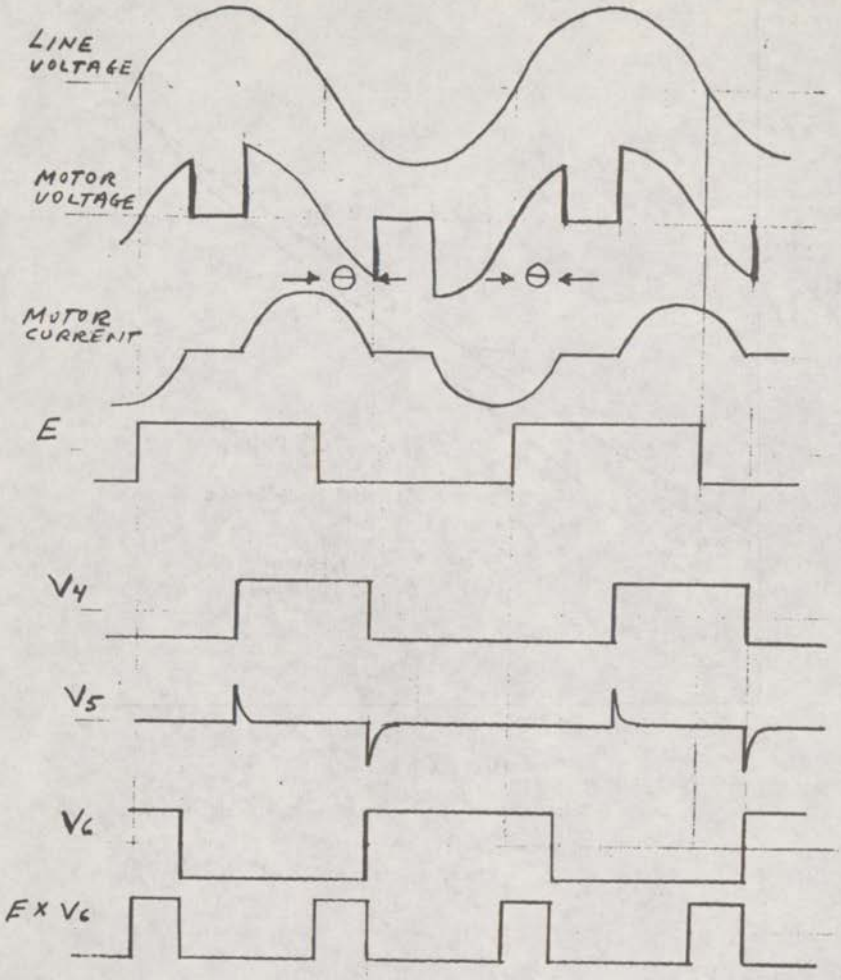
Most of the testing of the power factor control circuit has been done with motors loaded by a dynamometer. The response time of the dynamometer is a few tenths of a second. The stability of the system for step type loading needs investigating. The response time of this circuit is limited by the filter time constant required to smooth the phase angle voltage (output of U.C.).

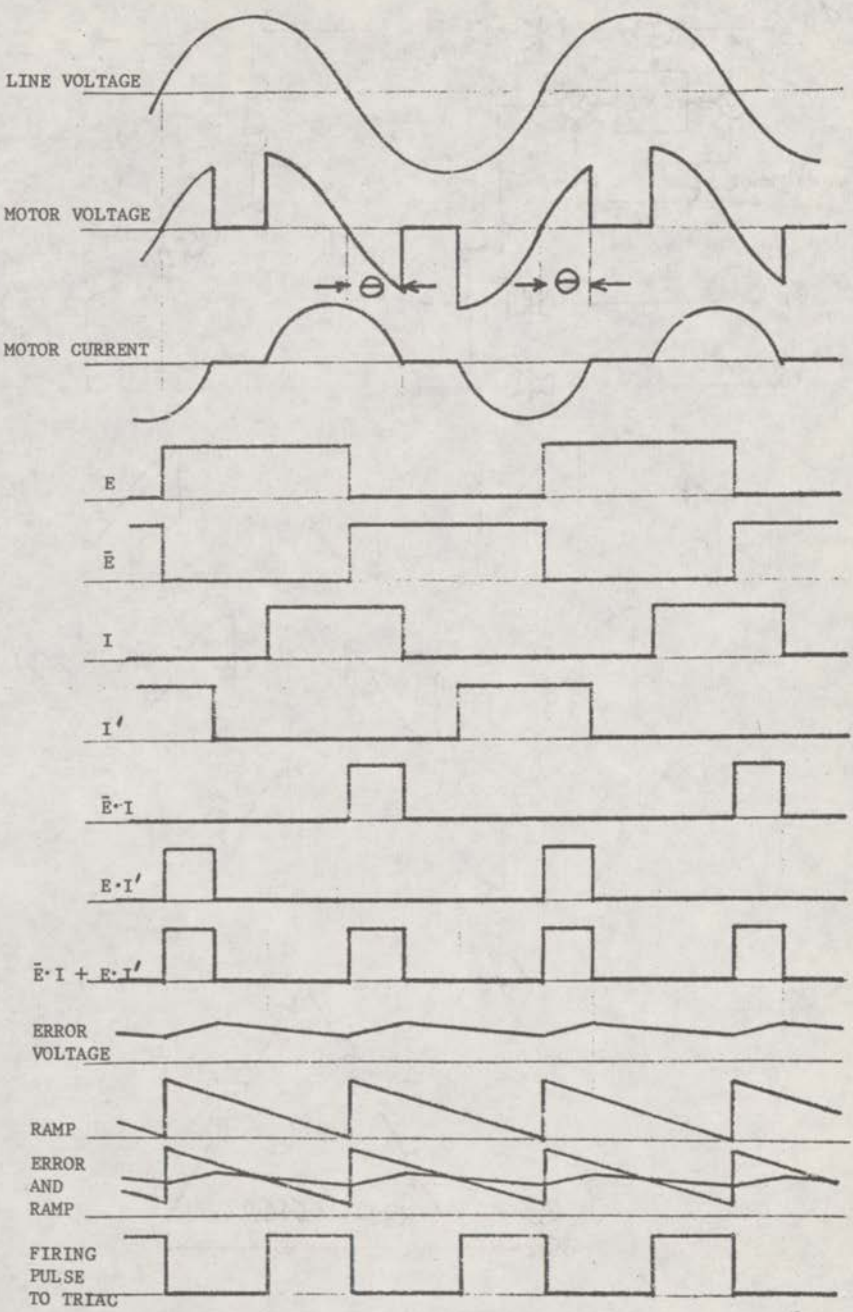
Our test has shown that the slow down of a fully loaded motor with this circuit in control is less than 2%.

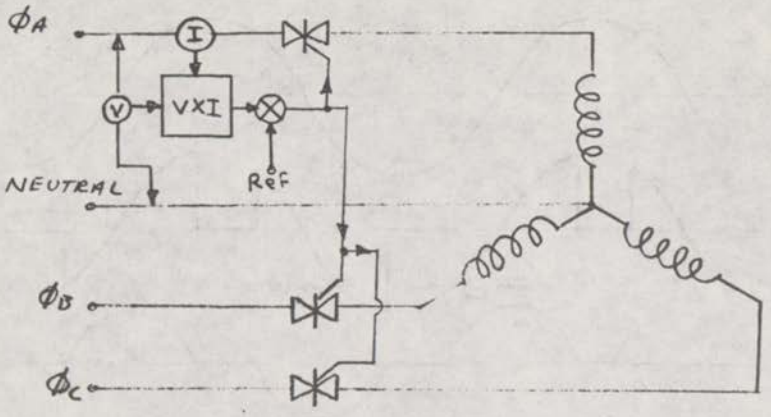
Single phase motors require no modifications to apply this controller. With wye connected 3-phase motors, we have found it necessary to connect to the wye internal to the motor. A triac with its firing circuitry is placed in series with each phase of the motor. The phase angle is sensed in only one phase and the error signal controls the 3 phases. To our knowledge the circuit has not been tried with a delta connected motor. We believe it will be necessary to place the triac in series with each winding inside the delta. Two voltage delta motors have all the necessary leads external to the motor so that no internal modification would be required.

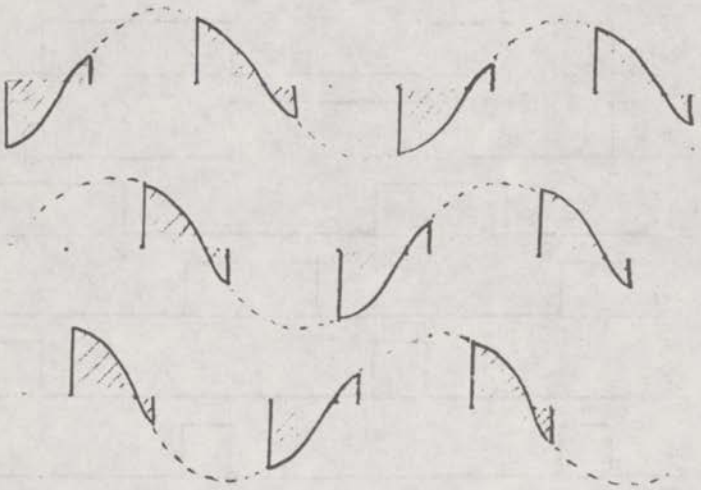
We believe that in certain applications, the cost effectiveness of applying this controller could be enhanced by having the circuit (with slight modifications) serve also as the on-off contactor for a motor or as a means of limiting starting inrush current in larger motors.

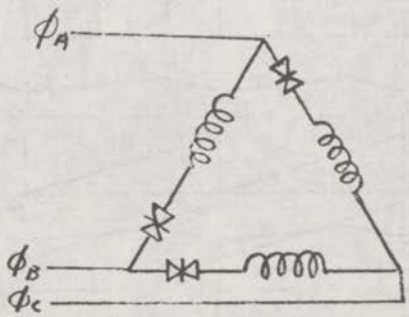

600
500
400
300
200
100
0
50
100
150
200
250
300
POWER (WATTS)
TORQUE (OZ IN)
1728 RPM
1746 RPM
1764 RPM
1776 RPM
1758 RPM
1782 RPM
1788 RPM
SCALE CHANGE
BELL & GOSSETT
1/2 HP 4 POLE
1/2 HP = 288 OZ IN
@ 1750 RPM


LINE VOLTAGE
MOTOR VOLTAGE
θ
θ
MOTOR CURRENT
E
V4
V5
Vc
E x Vc


LINE VOLTAGE
MOTOR VOLTAGE
θ
θ
MOTOR CURRENT
E
Ē
I
I′
Ē·I
E·I′
Ē·I + E·I′
ERROR VOLTAGE
RAMP
ERROR AND RAMP
FIRING PULSE TO TRIAC


ϕ_A
I
V
VXI
NEUTRAL
REF
ϕ_B
ϕ_C




ϕ_A
ϕ_B
ϕ_C

Enclosed are several circuits of the power factor controller which we have used. 50M25607 is the original concept which has been tested on over 35 motors with good results. The circuit is convenient to work with since the transformers provide isolation from the line voltage. It is however more complex and costly than 50M25606, Mod A and B.

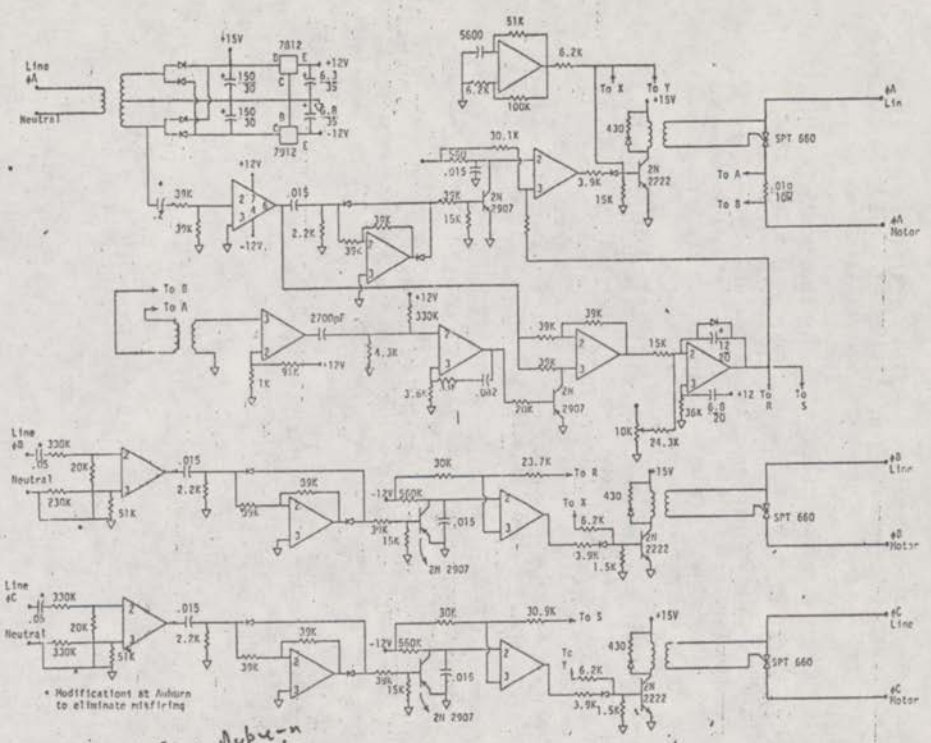
In Mod A and B, two transformers have been eliminated by connecting the common of the low level supply to one side of the line. Also the feedback signal is derived by "ANDING" and "ORRING" the voltage and current signals. This results in a simpler circuit.

Mod A and B have each been breadboarded and tested, and our ~~limited~~ experience indicates good results. In Mod A, the feedback signal is derived by sensing the phase angle only for the positive half cycles. The basic response of Mod B where the phase angle for each positive and each negative half cycle is sensed is twice as fast as Mod A. Mod A may be sufficient in many applications.

Also shown are the components (Note 5) which were added to respond to suddenly increasing or clutched in loads. The need for this additional circuitry should be determined for a given application.

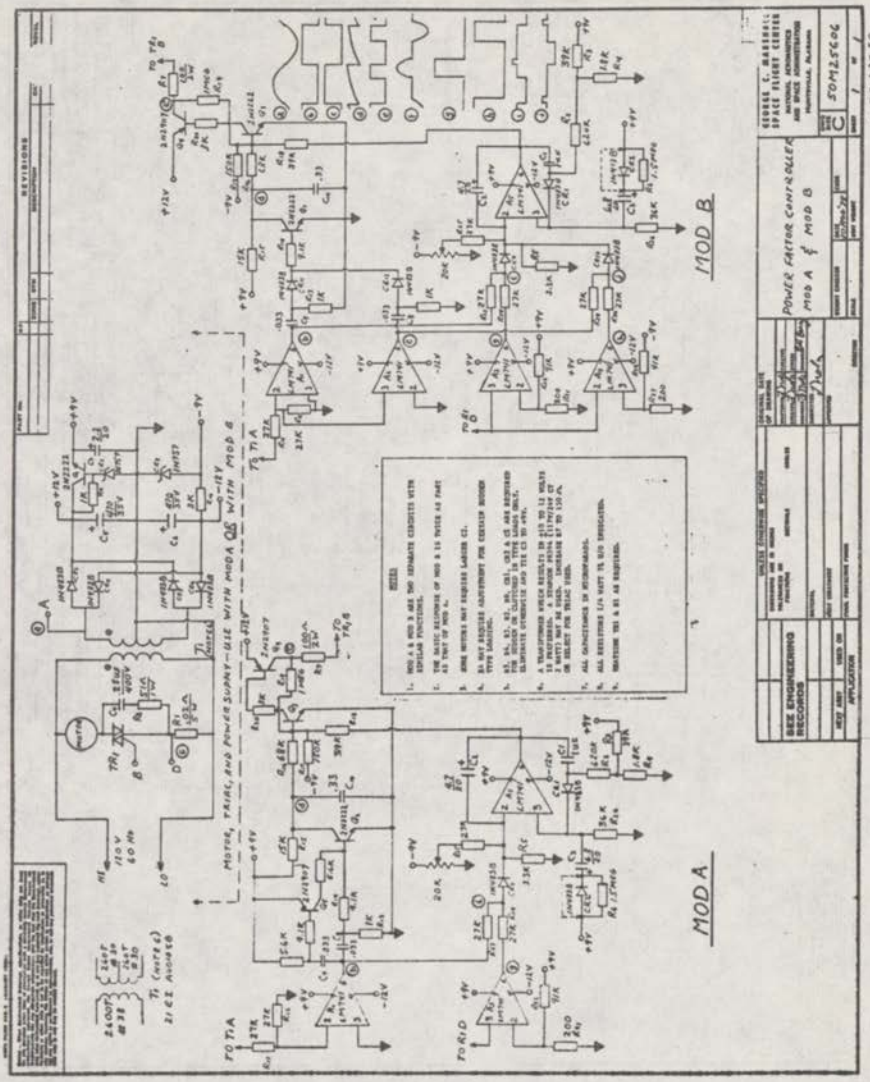
The speed of the basic circuit can be increased (within limits) by making R18 smaller. Speed is limited by the filtering required for the feedback signal.

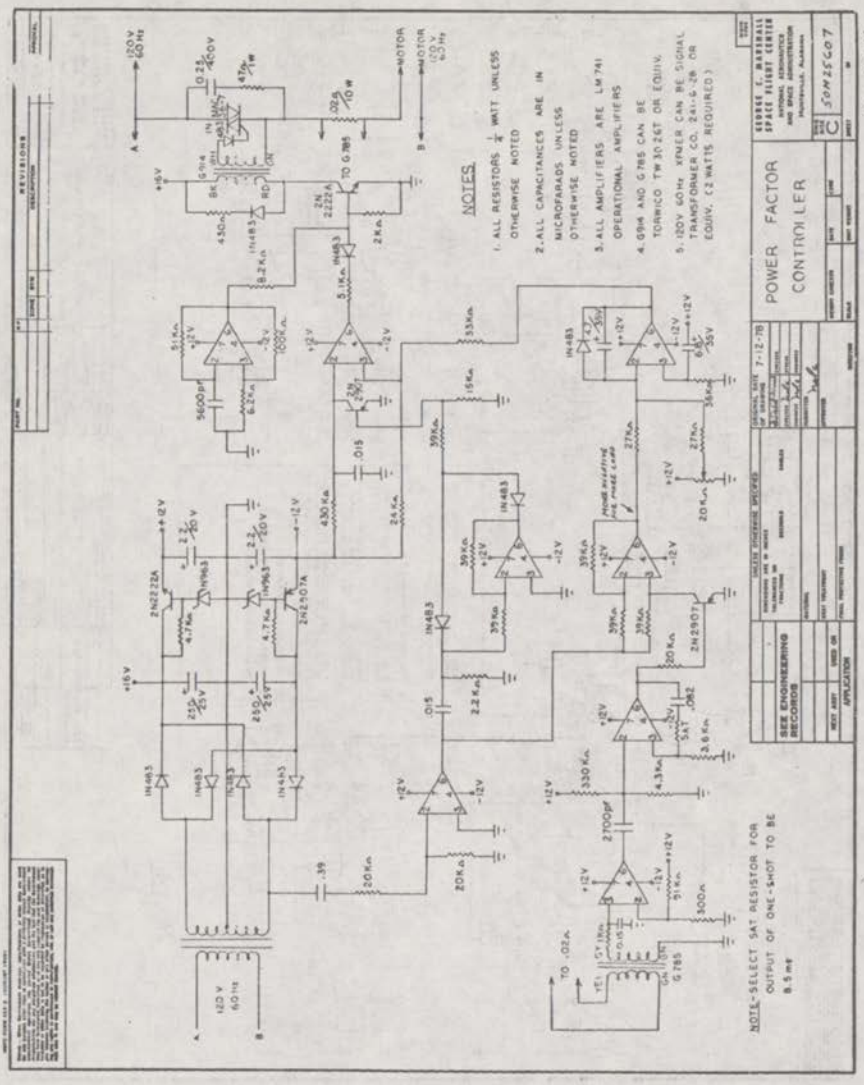
The small schematic is the 3 phase circuit which was used in the textile mill application. The Wye point of the motor was connected to the neutral of the 3 phase line.



From Auburn Report

ELECTRONIC POWER FACTOR CONTROLLER
Designed by Frank J. Nola for NASA


MOD A
MOD B
POWER FACTOR CONTROLLER
MOD A & MOD B
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NOTES


NOTES
1. ALL RESISTORS ¼ WATT UNLESS OTHERWISE NOTED
2. ALL CAPACITANCES ARE IN MICROFARADS UNLESS OTHERWISE NOTED
3. ALL AMPLIFIERS ARE LM 741 OPERATIONAL AMPLIFIERS
4. G914 AND G 785 CAN BE TORNICO TW30 26T OR EQUIV.
5. 120V 60Hz XFMER CAN BE SIGNAL TRANSFORMER CO. 241-6-2M OR EQUIV. (2 WATTS REQUIRED)
NOTE-SELECT SAT RESISTOR FOR OUTPUT OF ONE-SHOT TO BE 8.5 ms
POWER FACTOR CONTROLLER
SEE ENGINEERING RECORDS
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA
SIZE C
50M25607
7-12-78
REVISIONS

LICENSEES

For "Power Factor Control System for AC Induction Motors", U. S. Patent No. 4,052,648, NASA Case No. MFS-23280

1. Electronic Relays, Inc.
   1438 Brook Drive
   Downers Grove, IL 60515
   Attn: Joseph Pacente
   312/620-4646

2. IVECO (Improvement Via Electronics Co.)
   17402 Coronado LN.
   Huntington Beach, CA 92647
   Attn: Edward Yrissari, Gen. Mgr.
   714/842-2925

3. W. J. Purcell Co.
   4315 Myrtle Ave.
   Cincinnati, OH 43236
   Attn: Desmond J. Neville, Pres.
   513/791-1131

4. ADELET-PLM DIV.
   Scott and Felzer Co.
   4801 W. 150th St.
   Cleveland, OH 44135
   Attn: Maw H. Lee
   216/267-9000

5. Electronic Assemblies Co.
   1601 Hull Street
   Richmond, VA 23224
   Attn: Gerald F. Wilkinson
   804/231-0132

6. Energy Masters, Inc.
   3188 Airway Ave., Bldg. F
   Costa Mesa, CA 92626
   Attn: Palmer B. Ford, Pres.
   714/556-4921

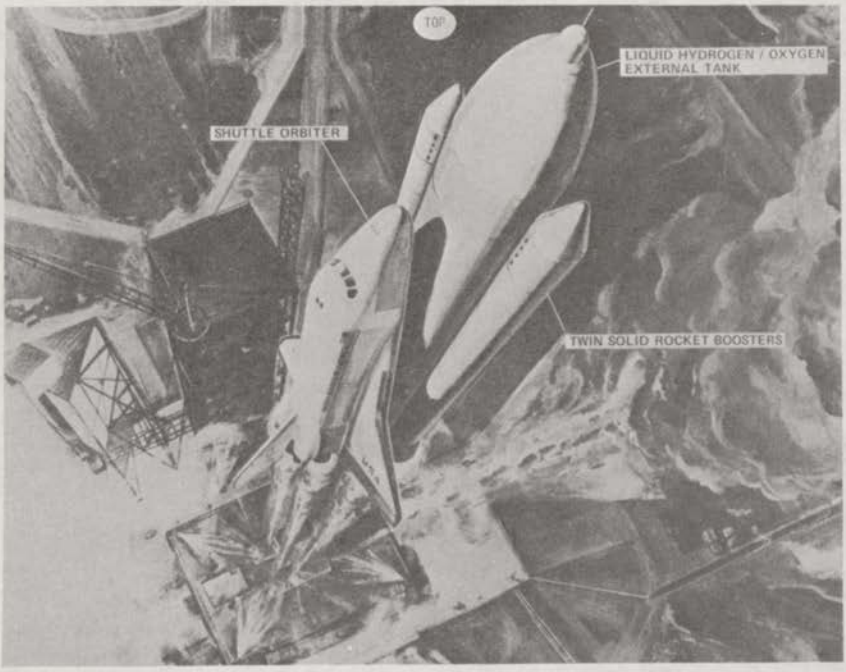
7. N.R.G. Products, Inc.
   P.O. Box 512
   Vineland, N.J. 08360
   Attn: Fred L. Hurban
   609/691-6699

8. Clinton Industries, Inc.
   700 Washington Ave.
   Carlstadt, N.J. 07072
   Attn: Angelo Pirrello
   201/935-4242

9. Energy Vent, Inc.
   423 Rita Street
   Dayton, Ohio 45404
   Attn: John Prikkel, P.E.
   513/222-7749

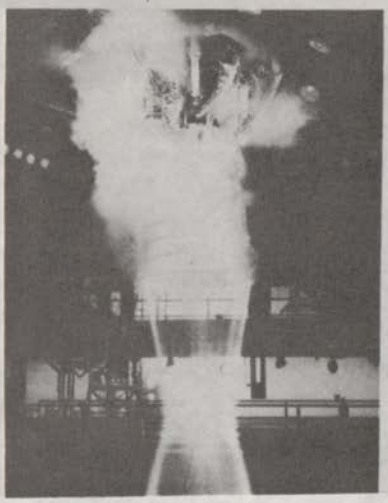
10. Controlled Power Corp.
    2542 237th St.
    Torrance, CA 90505
    Attn: Fred A. Meyer, Jr.
    213/539-5440

Dr. LOVELACE. Let me turn now to the Space Transportation System. This first picture is an artist's concept showing the major components of that system. These elements are all reusable, with the exception of the external tank.



The Shuttle main engine is shown in illustration 16. Three main engines are located on the aft end of the Shuttle orbiter. This high technology engine has presented a series of development difficulties for us, as you are aware.

SHUTTLE MAIN ENGINE TESTING AT NSTL



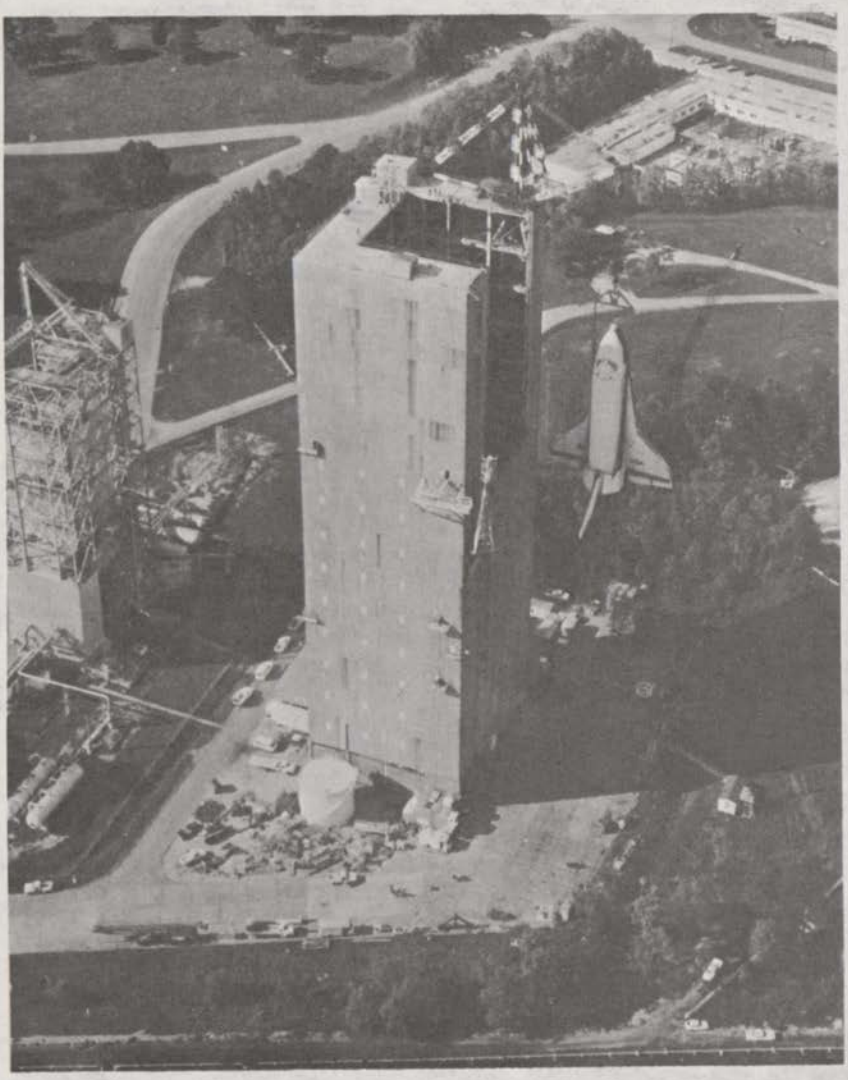


We have met and overcome a series of these difficulties. We stand today with some 35,000 total seconds of running time, with over a third of that test time at 100 percent rated power level.

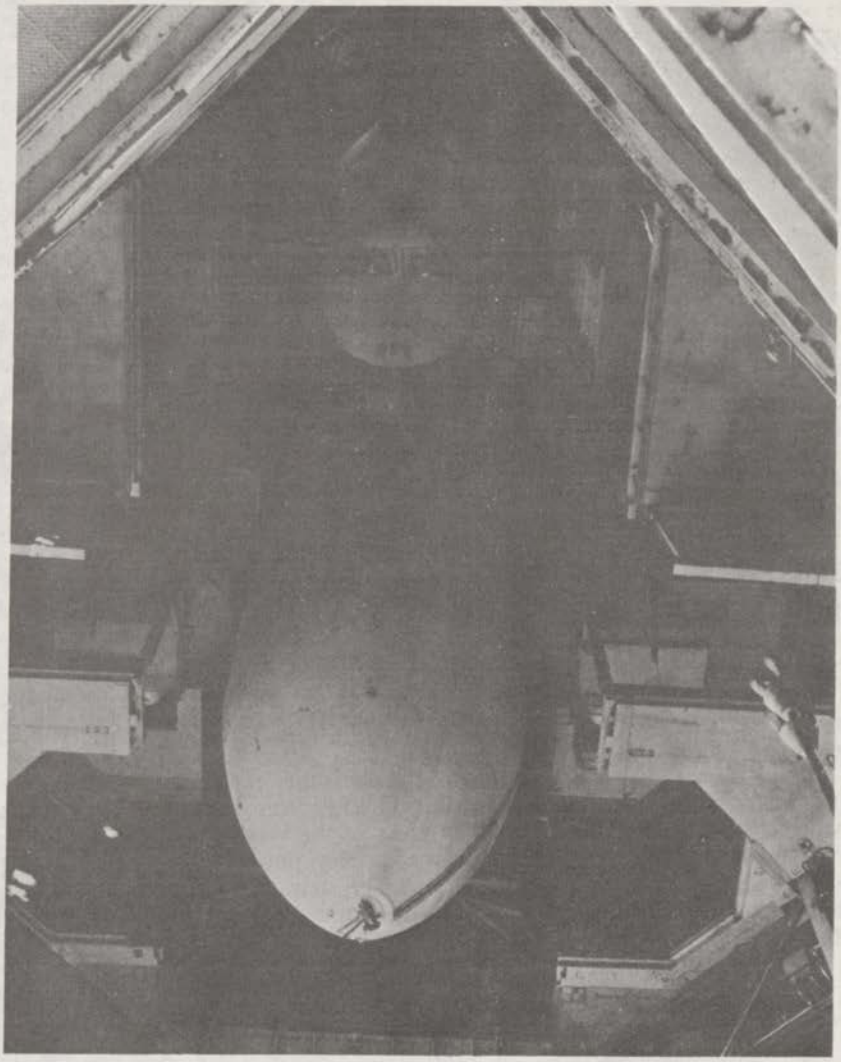
In the solid rocket booster area, we have successfully completed four tests of the solid rocket motors. Illustration 17 shows one of these tests at Wasatch, Utah. We have also successfully demonstrated the recovery of the solid rocket boosters.



The next illustration is one that you will recognize. It is a picture of the Orbiter Enterprise during the successful approach and landing tests.



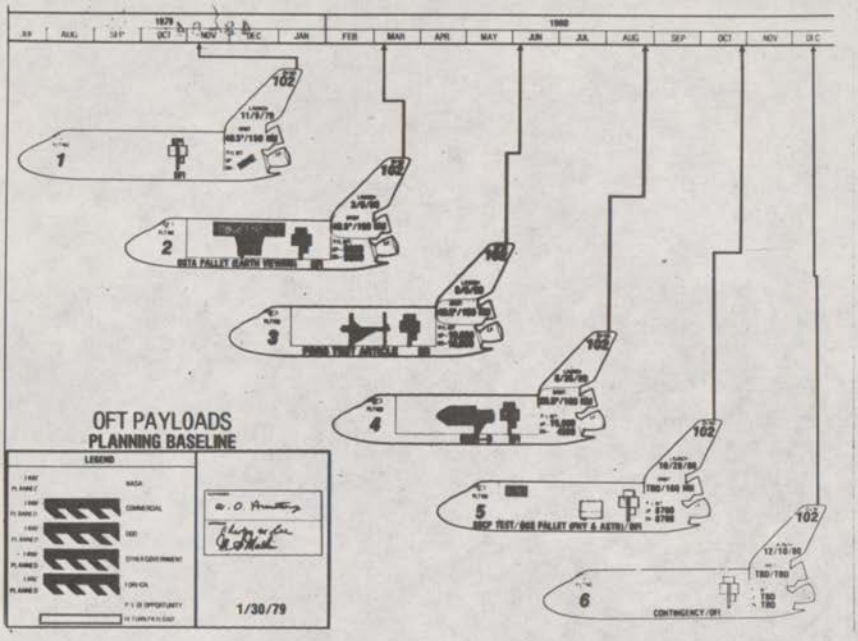
The next one is also the Enterprise test vehicle in another configuration that you may not recognize. The picture shows the Enterprise going into the vibration test cell down at Marshall Space Flight Center.



It was the first time that it had been mated up with the full configuration, solid rocket motors and external tank. A picture of that is shown on the next page. You see what we call the full stack in the mated ground vibration test mode in that test chamber. Those full-scale launch configuration tests have been completed, and have successfully validated our engineering models.

SPACE SHUTTLE SCHEDULED TEST FLIGHTS

The next illustration shows the current planning baseline for the orbital flight tests of the Shuttle. Six are planned now. I call your attention to the fact that the first manned orbital flight is now targeted for the ninth of November, 1979. That is the earliest possible date that we see for the first flight.



Mr. BOLAND. I see the launch date noted on the Shuttle flight schedule but I just wondered about the 40.5 degrees. What is that in reference to?

Dr. FROSCH. The 40.5 degrees is the inclination of the orbit and the 150 miles is the altitude of the orbit. The first number below that is the weight up and the number below that is the return weight, the payload weight. In other words, there are 5,600 pounds of payload going up in the second flight and there are 5,600 pounds coming back, because that is test instrumentation. Then you can see the figures for the other flight tests.

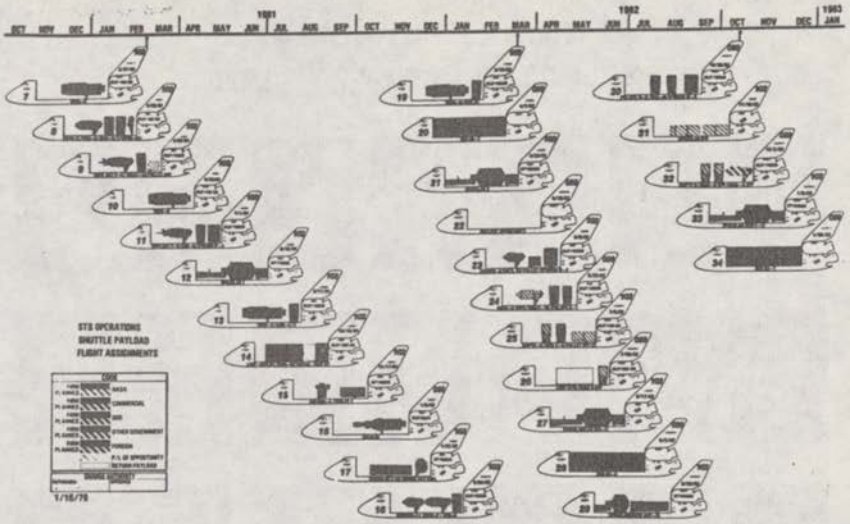
Mr. BOLAND. For flights one, two, and three, the only payloads are really NASA, correct?

Dr. FROSCH. For test instrumentation.

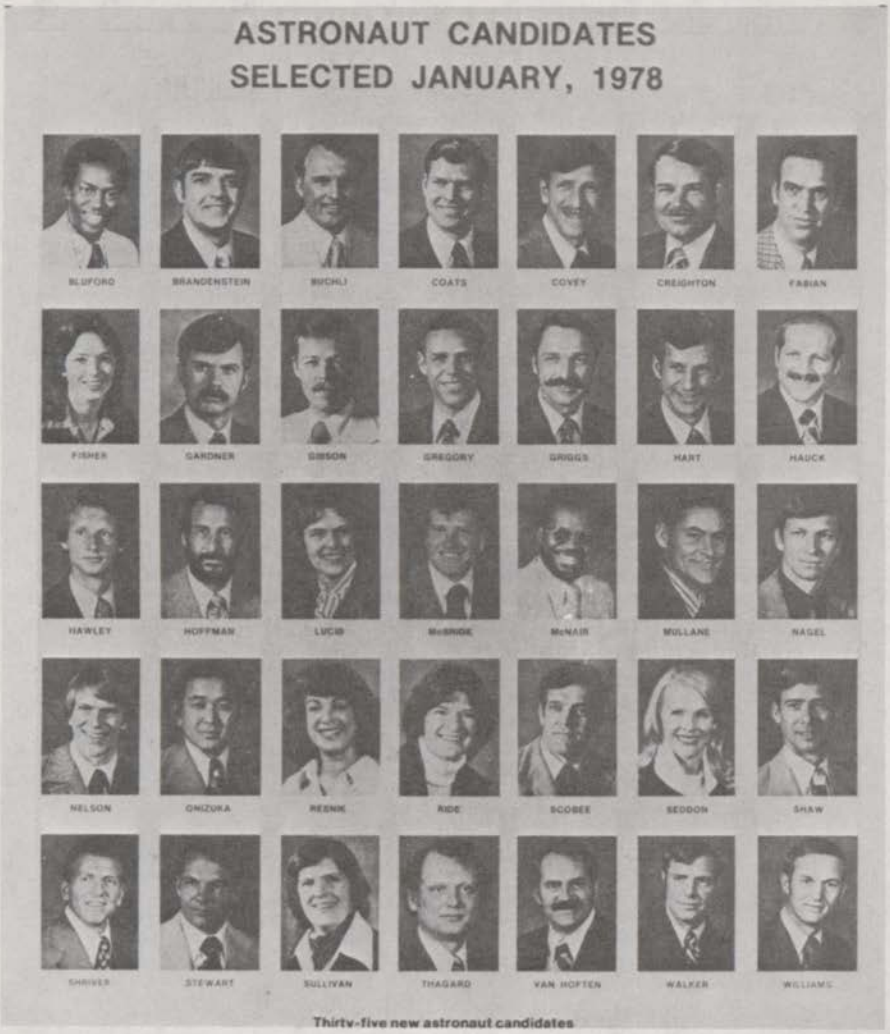
Mr. BOLAND. They are not payloads?

Dr. LOVELACE. There is a payload planned on OFT–4. It is the GOES–D, a Geostationary Operational Environmental Satellite. In any case, the first six flights are intended as tests.

The next illustration shows you the payloads that have been manifested through January, 1983. Some 28 operational Shuttle flights have been manifested, including the NASA commercial, DOD and other U.S. Government and foreign payload users that are signed up at this time.



Finally, we have selected 35 new astronaut candidates who, along with the current corps of astronauts, will provide the crews for the next several years of operation in the Space Transportation System. That concludes my presentation.



Thirty-five new astronaut candidates

Mr. BOLAND. Thank you very much, Dr. Lovelace.

Dr. FROSCH. Mr. Chairman, I would like to turn now to the major program areas outlining the highlights of our plans for Fiscal Year 1980, beginning with the Space Transportation System. The past calendar year was one of significant progress in testing, training, and construction in the Space Shuttle Program.

A major milestone will be reached this month when the first orbital flight vehicle, Columbia, will be shipped from the contractor's plant in Palmdale, California to the Kennedy Space Center in Florida.

SPACE SHUTTLE FY79 SUPPLEMENTAL FUNDING

Before reviewing our plans in the coming fiscal year for the Space Transportation System, I would like to briefly summarize the additional requirements in Fiscal Year 1979 which have caused our request for supplemental funding in the amount of $185 million.

At the outset, I wish to emphasize that this additional funding is an absolute necessity to continue the Space Shuttle Program at a pace that will minimize both total Shuttle development and production costs, and will also result in the earliest possible transition to the Space Transportation System with the significant flexibility and cost savings that it represents to all users.

We have estimated that failure to receive this supplemental funding in Fiscal Year 1979 on a timely basis would increase total Shuttle program costs by $400 to $600 million. Additional costs would arise to Shuttle payload users due to changes in mission planning if the current schedule isn't supported by adequate funding. The purchase of additional expendable launch vehicles would be required for early missions now planned for Shuttle launches.

Another major area of impact, more difficult to define, would involve the loss of payload benefits due to optimization for Space Transportation System (STS) launches. Several optimized payloads would have to be redesigned for compatibility with both expendable and STS launches, resulting in cost penalties and postponing the economic benefits of the expanded capabilities inherent in the STS. As a result, the overall impact of failure to receive the additional requested supplemental is estimated to be in excess of a billion dollars.

The need for additional appropriations in Fiscal Year 1979 arises from deferred work and additional engineering and manufacturing effort over all the elements of the Shuttle program. A large increase in the number of secondary structures and certain necessary system changes in the first orbital flight vehicle, Columbia, both contributed to making the final assembly and checkout more complex, time consuming, and costly.

In the production of thermal protection system tiles for the orbiter, new processes had to be developed to produce dimensionally correct tiles. While the problem of the sequence of manufacturing has been largely solved, deferral of substantial TPS installation activity to the Kennnedy Space Center will be required.

During Fiscal Year 1978 and early Fiscal Year 1979, the main engine deliveries for Columbia have slipped seven months. This was mainly due to engine test failures and fires, with severe damage to three engines. As a result of these difficulties, we have retargeted the date for the first manned orbital flight to November 9, 1979. While this date represents a tight, "all-success" target schedule, we believe that there is good probability of accomplishing the STS–1 launch before the end of this calendar year.

Our Fiscal Year 1980 budget request and Fiscal Year 1979 Shuttle expenditure plan are predicated on the availability of the requested supplemental funding. If this additional funding is not forthcoming, a major program restructuring will be necessary, incurring a delay of four to six months in the first orbital flight, a six to twelve month

delay in delivery of the second, third, and fourth orbiter flight vehicles, and total cost penalties in excess of a billion dollars as discussed above.

FY 1980 SPACE SHUTTLE BUDGET REQUEST

In Fiscal Year 1980, we are requesting a total of $610.5 million for Shuttle design, development, test, and evaluation. A significant portion of this funding will be directed toward the four orbital flight tests presently planned for that fiscal year. The first flight will be configured to maximize crew and vehicle safety and the following flights will extend the envelope and complexity of operations. Present plans call for an Earth-viewing space applications pallet mission on the second flight, a test of the remote manipulator system on the third, and the launch of a Geostationary Operational Environmental satellite (GOES–D) on the fourth test flight.

We are also requesting a total of $755.5 million for continued fabrication and assembly leading to an operational fleet of four orbiters which were formally named last month: Columbia, Challenger (presently the structural test article), Discovery, and Atlantis. Funds appropriated in Fiscal Year 1979 to preserve an option for a fifth orbiter are being applied to long-lead items common to either a four or five orbiter fleet.

In Space Flight Operations, the total request of $467.3 million includes the funding for flight hardware for the early STS operational flights now scheduled to begin in February, 1981. We are essentially fully booked on the Shuttle manifest for the first two years of STS operation. A visual display of this manifest is attached to my statement. The request also includes continued incremental procurement of the second set of Spacelab hardware from the European Space Agency; NASA-unique requirements for the DOD's inertial upper stage; and hardware procurements of the spinning solid upper stage, which is currently under private development. We are also requesting $15 million for analysis and initial design of a thrust augmentation option for the Shuttle to increase its payload deployment capability.

Advanced Programs, for which we are requesting a total of $13 million, will focus on mission options to enhance the unique capabilities of the Shuttle. We will investigate advanced power systems, including the completion of definition studies and evaluation of the 25 KW power systems, techniques for construction of space structures, solar electric propulsion, and orbital transfer vehicles.

The contract for development of the Teleoperator Retrieval System, which was to be used to reboost or deorbit the Skylab was terminated on December 18, 1978. After closeout of the subsystem contracts, any residual Fiscal Year 1979 funding will be used to support Shuttle activity, in accordance with the language of the Fiscal Year 1979 Appropriations Conference Committee Report.

Our request of $70.7 million for Expendable Launch Vehicles is earmarked for the Scout, Centars, Delta, and Atlas–F vehicle requirements as we transition to the STS.

SPACE SCIENCE PROGRAMS FY 1980 BUDGET

In Space Science, a total of $601.6 million is requested for Fiscal Year 1980 Space Science R&D programs. No major new flight pro-

grams are included. This request provides the necessary support for the continued development of the Space Telescope, the Galileo Mission, the International Solar Polar Mission, and experiments to be conducted on Spacelab missions. It will also continue operations of current missions.

A total of $112.7 million is requested for continued development of the Space Telescope. Currently scheduled for a Shuttle launch in 1983, this unique instrument will form the centerpiece of our astronomy program for the remainder of the 1980s and beyond. It is being designed for in-orbit maintainance and repair by the Shuttle; it will also be recoverable and can be refurbished.

This budget request also provides for the refinement of plans and requirements for the operational era of the Space Telescope. We have concluded that the best approach to maximize the scientific returns from the program will involve the establishment of a Space Telescope Science Institute operated under a long-term contract with NASA. We currently plan to release a Request for Proposal early in Fiscal Year 1980 for the operation of the institute.

The major focus of our near-term planetary program will be the Galileo Jupiter Orbiter and Probe. This challenging mission, scheduled for launch in early 1982, will use the full capability of the Shuttle and provide indepth information on the Jovian atmosphere and its fascinating satellites. A total of $116.1 million is requested to continue the Galileo development in Fiscal Year 1980.

Solar/Terrestrial Research will continue at a strong pace, with central activities based on the Solar Maximum Mission to be launched in 1979, and the International Solar Polar Missions, planned for launch in 1983; this is a joint mission with the European Space Agency.

The Life Sciences Program, for which a total of $43.9 million is requested, will emphasize inflight experimentation, thus taking advantage of the laboratory atmosphere which will be available in the Spacelab.

SPACE AND TERRESTRIAL APPLICATIONS PROGRAMS FOR 1980

In Space and Terrestrial Applications, we are requesting a total of $344.4 million. No major new flight projects are included in this request. The Space Applications Program budget request is $332.3 million. Of this amount, $141.4 million will be applied to Resource Observations Programs, with emphasis on agricultural research, and on the continued development of Landsat–D.

A total of $117.2 million is planned for the Environmental Observations Programs. With the transfer of the Upper Atmosphere Research Program from the Office of Space Science to the Office of Space and Terrestrial Applications, environmental research within NASA is now focused in Space Applications.

Major thrusts of the Environmental Observations Programs in Fiscal Year 1980 are directed toward an understanding of the physics and chemistry of the environment. A major research initiative, which will begin in Fiscal Year 1980, is a joint cooperative program with the Departments of Agriculture, Commerce, Interior, and the Agency for International Development in crop monitoring and commodity production forecasting.

43-843 O - 79 - 7

NASA, building on experience gained in the Large Area Crop Inventory Experiment, will develop and test remote sensing techniques to provide both commodity production forecast and early warning of changes affecting crop production or quality.

The President's space policy directs NASA to support U.S. technological leadership in communication satellite systems. In the budget request before you today, NASA is proposing to reenter selected areas of this sector of research and development. We will concentrate on the development of the technology required to increase the usable capacity of the radio frequency spectrum for communications satellites in geosynchronous orbit.

Work will also continue on the Search and Rescue Demonstrations project—a joint project with Canada, France, and the USSR—as it progresses toward a 1982 first flight.

We are requesting $12.1 million for Technology Utilization, as compared to $9.1 million for Fiscal Year 1979. This program continues to provide important benefits to the Nation from aerospace research and development. We plan added emphasis on stronger interaction with the private sector in Fiscal Year 1980. Of the $3 million increase, $2.4 million represents the transfer of civil systems activity into Technology Utilization.

AERONAUTICS AND SPACE TECHNOLOGY FUNDING

In Aeronautics, our Fiscal Year 1980, R&D budget request is $300.3 million. Our primary efforts will be directed toward strengthening the technology base, continuing progress toward energy-efficient aircraft, and continued noise, pollution, and safety research.

Fiscal Year 1980 marks the year for peak activity in our total Aircraft Energy Efficiency Technology Program, with total requested resources of $116.1 million. The program is aimed at providing improved technology leading to a major reduction in fuel requirements for transport aircraft.

Rotorcraft technology efforts will stress advances to improve terminal operations, efficiency, and flight worthiness. General aviation activities will focus on noise and emission reduction, flight worthiness, and advanced low-cost avionic systems.

Technology for vertical-takeoff-and-landing aircraft and high-performance aircraft will be conducted primarily in support of current and future military requirements.

A strong generic research and technology base has been the foundation of this country's leadership in aviation. We propose a total of $117.5 million for these activities.

Our Space Research and Technology Program, for which we are requesting $116.4 million for Fiscal Year 1980, will continue to support the needs of current and future space missions and to formulate approaches which will increase the reliability and efficiency of future missions.

A total of $3 million is proposed for continued work to identify the technology generated in our Aeronautics and Space Program which has potential for major contributions to the solution of our energy problems. We will also continue our highly successful efforts in our support of the Department of Energy in such areas as solar cells, solar

heating and cooling, and wind machines. I am pleased to note that the President is requesting $8 million for DOE for solar power satellite research in Fiscal Year 1980, an increase of $3.5 million. We will continue our joint study efforts with DOE in this area, with NASA continuing its systems definition efforts on a reimbursable basis.

TRACKING AND DATA ACQUISITIONS FY 1980

In Space Tracking and Data Systems, we are requesting a total of $332.8 million for continuation of tracking and data acquisition support for Earth-orbital spacecraft, planetary missions, sounding rockets, and research aircraft. The Fiscal Year 1980 workloads remain high.

A major aspect of the Tracking and Data Acquisition Program in future years will be the Tracking and Data Relay Satellite System, which will replace most of our ground-based systems and will support essentially all Earth orbital tracking and data acquisition capabilities in the Shuttle era.

For Construction of Facilities, we are requesting a total of $157.6 million, an increase of approximately $10 million over Fiscal Year 1979. Of this total, $12 million is for completion of construction of the National Transonic Facility begun in Fiscal Year 1977 at the Langley Research Center. A total of approximately $31.5 million is requested for Space Shuttle facilities, primarily related to launch requirements at the Kennedy Space Center and the external tank manufacturing and final assembly areas at the Michoud Assembly Facility in New Orleans.

The Civil Service personnel funded by this appropriation represent NASA's most important resource and are the strength on which our world leadership in space and aeronautics depends. Three-fourths of this appropriation is required for their salaries and related costs. About two percent is for travel which is vital to the management of our R&D programs. The balance is for facility support and related goods and services. Our Research and Program Management request for Fiscal Year 1980 totals $964.9 million.

The austerity of the Fiscal Year 1980 budget, as well as the Congressional mandate in the Civil Service Reform Act for reducing Federal manpower levels in Fiscal Year 1979, necessitate an overall reduction of 674 in the NASA permanent Civil Service personnel ceiling. This reduction will be phased through Fiscal Years 1979 and 1980.

In conclusion, I believe the President's budget request comprises a sound, balanced aeronautics and space program. This request provides a good but tightly constrained foundation for meeting the stated goals of civil space policy and will permit the United States to maintain its leadership in space science applications, technology and aeronautics. It also fully supports the continued development of the Space Transportation System, meets commitments made in the past, maintains progress in ongoing programs, and provides for some flexibility in future programs. The President's Fiscal Year 1980 budget request is tight but sufficient to continue our transition to the Shuttle era in a time of fiscal stress.

Mr. Chairman, we have touched on the highlights of our Fiscal Year 1980 request and we would be happy to try to answer whatever questions the Subcommittee might have.

SHUTTLE SCHEDULE SLIPPAGE

Mr. BOLAND. Thank you very much, Dr. Frosch. Let's begin by looking at the Shuttle schedule for a few minutes. Last year during the joint hearings on the Space Transportation System/Shuttle, I asked if the target date for the first launch was June 1, 1979 and John Yardley responded as follows,

"Our target date is still March. June is our external date. We are fairly comfortable with June. We think there is a fairly low possibility that we will launch in March".

Last September the Agency officially slipped the first launch to September 28, 1979 and after the major engine explosion this past December, the first launch was again slipped to November 9, 1979.

Now we have the Covert Report. Eugene Covert is a distinguished scientist at MIT and chaired an ad hoc committee for review of the Space Shuttle and main engine development program. This ad hoc committee was put into place as a result of the recommendation of the Subcommittee on Science, Technology and Space of the U.S. Senate Committee on Commerce, Science, and Transportation. This ad hoc committee is part of the National Research Council. I will place in the record at this point what the National Research Council is, and clearly indicate that it is a very valuable council and the people that served on this ad hoc committee are a list of distinguished individuals in business and in the universities. We will put the list of those people in the record at this point, as well as a copy of the National Academy of Sciences Report.

[The information follows:]

The National Research Council was organized by the National Academy of Sciences in 1916 in order to provide for a broader participation by American scientists and engineers in the work of the Academy. The Academy was chartered by the U.S. Congress in 1863 as a private organization with a responsibility for examining questions of science and technology at the request of the Federal Government. The National Academy of Engineering was organized in 1964 under the original NAS charter. The National Research Council now serves as the agent of both Academies in the conduct of studies and investigations in the public interest.

Second Review— Technical Status of the Space Shuttle Main Engine

A Report of the
Ad Hoc Committee for Review of the
Space Shuttle Main Engine Development Program

Assembly of Engineering
National Research Council

NATIONAL ACADEMY OF SCIENCES
Washington, D.C. February 1979

NOTICE

The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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SPACE SHUTTLE MAIN ENGINE DEVELOPMENT PROGRAM

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IN MEMORIAM

As this report was going to press early in February 1979, the members of the committee were saddened by the death of Robert B. Young, a distinguished colleague and a major contributor to their deliberations and conclusions.

PREFACE

In December 1977, concerned with delays in the development of the main engines for the maiden voyage of the space shuttle, the Subcommittee on Science, Technology, and Space of the U.S. Senate Committee on Commerce, Science, and Transportation asked the National Research Council to review the situation. In January 1978, the Research Council established the ad hoc Committee for the Review of the Space Shuttle Main Engine Development Program, under the Assembly of Engineering. By the end of March of that year, the ad hoc Committee had issued its report, Technical Status of the Space Shuttle Main Engine, and its chairman, Eugene E. Covert, had testified before the Senate Subcommittee.

In view of the concerns about several critical components in the main engine and the uncertainties in maintaining the planned schedule for the first manned flight of the space shuttle, Senator Adlai E. Stevenson, the Subcommittee's chairman, requested at the conclusion of the public hearing on March 31, 1978, that the ad hoc Committee should perform another examination of the development program in the fall of 1978. Accordingly, the review committee met October 30-31, 1978, at the National Space Technology Laboratories, Bay St. Louis, Mississippi, where the main engine is being tested.

The committee's assessment took account of two sets of problems -- some that were considered in its earlier review and continue to cause concern and those that have appeared during the engine tests since March 1978. In its first report the committee had concentrated on the engine for the first manned flight. In the subsequent review it gave more emphasis to longer range matters of the main engine system.

During December 1978, as the second report was nearing completion, the engine development program encountered two setbacks. On December 5, 1978, a fire occurred as a result of a leak in the heat exchanger of a test engine--a component the review committee had singled out for concern in its first report. On December 27, a fire originating in the main oxygen valve nearly destroyed another engine.

As a direct consequence of these incidents, the Senate Subcommittee called on the ad hoc Committee to review the latest problems and reexamine its previous findings and conclusions before submitting its second report. Thus, the review committee met again February 1-2, 1979, at the National Academy of Sciences in Washington, D.C., to hear the accounts of the origins and consequences of the incidents and to deliberate on their implications for the development of the shuttle's main engine.

This report contains the findings and recommendations of the review committee as a result of its meetings in October 1978 and February 1979.

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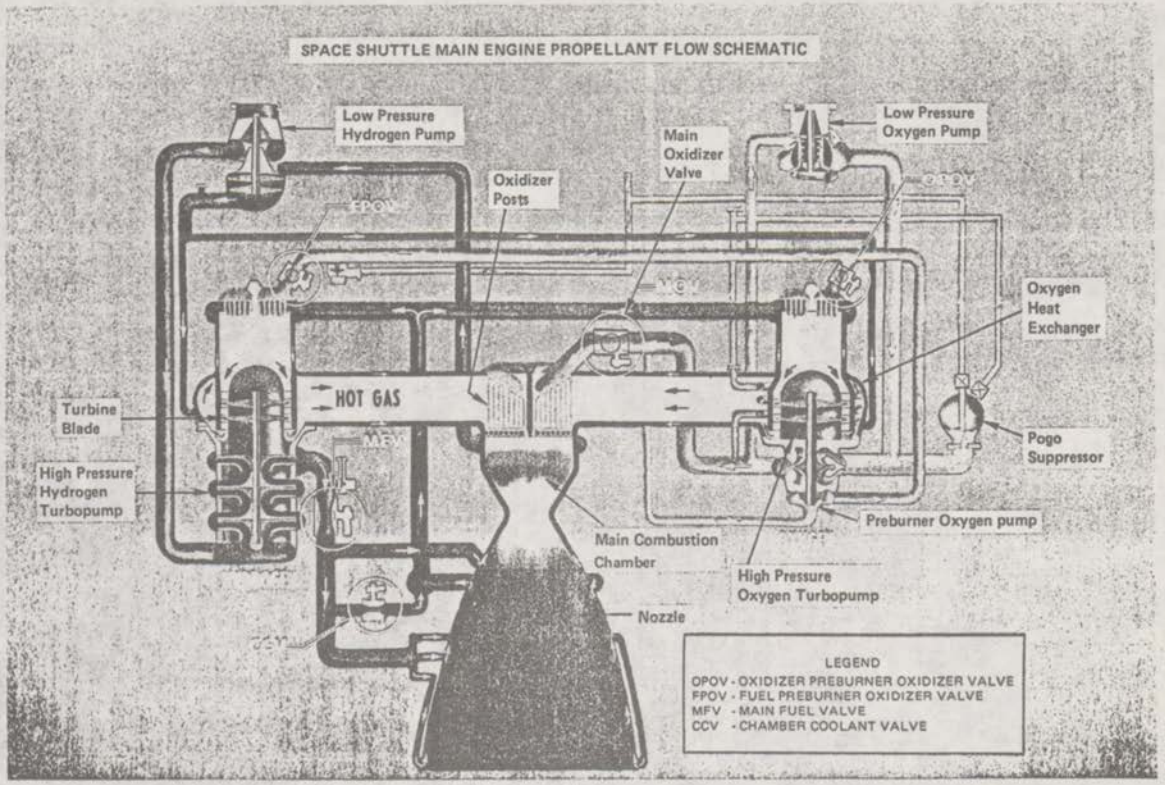
INTRODUCTION

The space shuttle, a winged spacecraft designed to carry a number of people and a large payload into space and to return to earth for subsequent reuse, is regarded as significant to America's future in space. During its development, even as late as 1978, the main engine for the space shuttle encountered a succession of problems -- many of them, however, typical of those usually experienced in the early stages of a major technological advance. The solutions to these problems have required the redesign of some components in the main engine and the modification of others.

Existing rocket engines are insufficient for the shuttle, and even new engines of conventional design cannot attain the performance level required. The shuttle is to be powered by three main engines, using a staged-combustion cycle for high efficiency and operating on hydrogen and oxygen at a chamber pressure of 3,000 pounds per square inch -- several times more than previous flight engines. Each engine must deliver up to 1,668,000 newtons (or 375,000 pounds) of thrust at sea level, with the highest combination of thrust-to-weight ratio and specific impulse ever required in a rocket unit (see Figure 1).

In its first report, the committee had observed:

> The development of such an operational engine requires a greater step forward in technology over the J-2 rocket, which was used in the two upper stages of the Saturn vehicle that launched the Apollo spacecraft to the moon, than the J-2 did over its predecessor, the RL-10 engine. However, any risk involved in making such an advance is reduced by the knowledge and experience gained through the development of the USAF Rocket Propulsion Laboratory - Pratt & Whitney experimental XLR-129 engine and the subsequent NASA Marshall Space Flight Center - Pratt & Whitney turbo-machinery program that produced turbopumps for an engine of 350,000 pounds of thrust. These two programs were experimental and, in fact, were not intended to reach the operational stage. Nevertheless, they clear-



Adapted from an Engine Diagram by Rocketdyne Division Rockwell International.

FIGURE 1

ly anticipated the successful development of the space shuttle main engine.[1]

The National Aeronautics and Space Administration (NASA) and the builder of the main engine, Rocketdyne Division of Rockwell International Corporation, decided to use a "success-dependent" strategy for developing the engine. This strategy is a departure from the traditional procedure of development stages in that component-development testing was foreshortened and the quantity of spare parts was severely limited. The success-dependent procedure was intended to offer potential savings in cost and time, by eliminating parallel and possibly redundant development and test hardware. However, as the committee noted in its earlier report, if or when malfunctions occur during the testing of the prototype of the operational engine, new hardware may need to be designed, constructed, and retrofitted, resulting in delays. That is what happened. The main engine program has been beset with technical problems related mainly to the rotating machinery. Although some of the problems were unresolved at the time of the earlier study, when the committee conducted its follow-up review in October 1978 both NASA and Rocketdyne reported that (in their opinion) solutions to the problems, adequate for the first manned orbital flight, had been identified and in most cases tested. In fact, significant progress had been made and the rate of testing had proceeded toward NASA's goal of 80,000 seconds of test time before the first manned flight (rescheduled from March 1979 to September 1979).

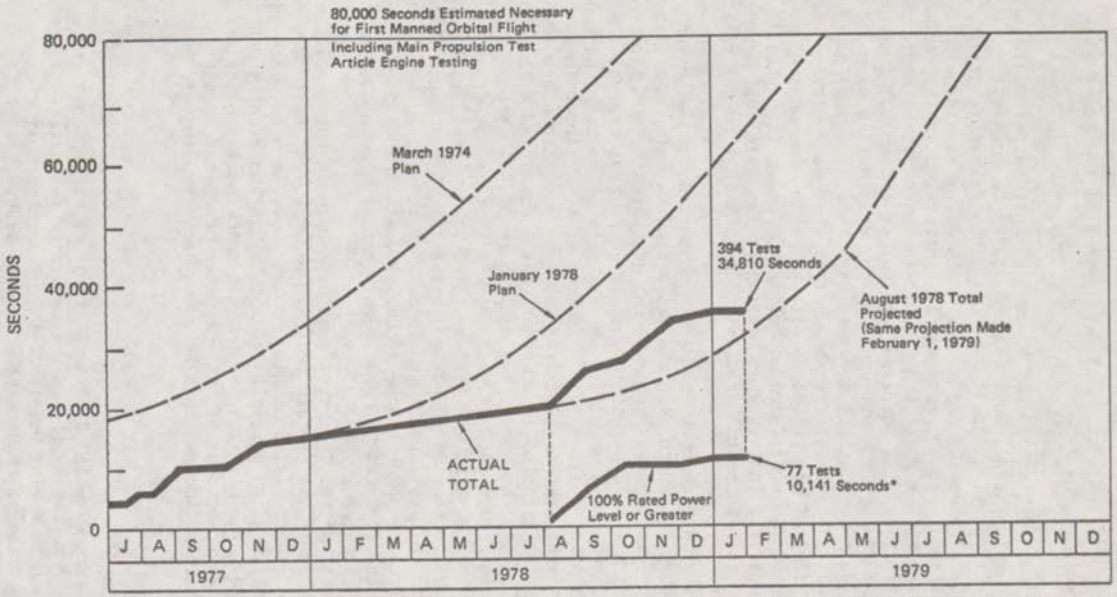
Since the committee's first report, the accumulated test time as of December 27, 1978, has more than doubled to 34,810 seconds in 394 firings (see Figure 2). Of this total, a little more than 10,000 seconds has been at 100 percent rated power level, with seven tests run at 100 percent rated power for the full 520 seconds that the main engine operates during the launch. Furthermore, a test run at 102 percent rated power has been completed and an "abort and return-to-launch-site" test of 823 seconds has been made at approximately 97 percent rated power.

Because most of the long test runs have been on one particular engine (0005), it is not certain that all the problems have been solved. Not unexpectedly, some new problems have been encountered. These may constitute new obstacles to maintaining an orderly schedule for the shuttle. The committee's specific concerns are described and evaluated in later sections of this report. Here, the committee deals with previous concerns that have now been disposed of.

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[1]National Research Council, Technical Status of the Space Shuttle Main Engine. A report by the ad hoc Committee for Review of the Space Shuttle Main Engine Development Program, Assembly of Engineering. National Academy of Sciences, Washington, D.C. March 1978, pp. 1-2.

ACCUMULATED ENGINE TEST DURATION



*Includes one test in November 1978 at 102% rated power level for 296 secs. This test and the other tests at 100% rated power are included in the total accumulation of 394 tests.

SOURCE: Based on NASA data.

FIGURE 2

In its first report, the committee had recommended the initiation of an alternative design for the shaft and housing of the high-pressure oxygen turbopump. NASA and Rocketdyne have responded fully to this recommendation with a preliminary redesign involving bearing relocation and housing redesign. In addition, they have made design changes to the present high-pressure oxygen turbopump. Such changes have the goal of achieving reliability for the early flight missions. Some of the design changes have not only been completed but the hardware is now being fabricated. The performance resulting from such changes will be evaluated in the near future. During its review, the committee has learned of a new design that has the potential for marked improvements in the performance of seals and the reliability of the high-pressure oxygen turbopump. If the space shuttle is to become a successful space transportation system, such improvements will be needed.

The first manned flight and the completion of the six orbital flight tests are major milestones in the development of the operational space transportation system for the 1980's. The later development of the operational engine includes increasing its thrust rating to at least 109 percent of rated power level, which is sometimes called full power level, and developing the capability for safe and reliable operation over a life of 55 missions, which means about 7-1/2 hours or 27,000 seconds of engine running time, with maintenance comparable to that of commercial transport aircraft engines.

The development of such a life span is not necessary for the first six orbital flights. In fact, to require such a lifetime capability by 1979 or 1980 would be unrealistic and would result in inordinate delays in the overall space shuttle program. Because high reliability, long engine life, and performance (in terms of power level) cannot be attained simultaneously within the schedule, the current approach is to emphasize reliability at the rated power level (100 percent) at the expense of engine life and full power level (109 percent rated power). The committee considers this order of priority appropriate. Thus, the successful completion of the first six orbital flight tests does not signify the end of the main engine development. Substantial further development must proceed to elevate the thrust level to 109 percent of rated power with high reliability and 7½ hours life.

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Tear-down Inspection After First Flight

In its earlier report, the committee recommended a complete tear-down inspection of the main engine after the first and sixth flights. In the view of some rocket engine experts, however, a tear-down inspection should be avoided unless visual inspection, including the use of a borescope,[1] indicates otherwise. This is based on the hypothesis that unless distress is visible or is indicated by a deterioration of performance, it is best not to disassemble a working engine. However valid this may be, some loading conditions are not encountered until the system is flown -- for example, consider the loads implied by the firing of solid rockets, maneuver loads, and acoustical vibrations. The committee considered three approaches: (i) a complete tear-down inspection of the three main engines after the first flight; (ii) a complete tear-down inspection after the third flight unless the visual inspection, borescoping, and data indicate that an engine is distressed after an earlier flight; and, (iii) a thorough inspection of one of the main engines after the first flight, with the tear down of only the two high-pressure turbopumps (and replacement of this engine with a spare).

On balance, the argument reduces to a simple point. In a closely coupled engine, with high thrust-to-weight ratio, where the performance could seriously deteriorate if some component fails to work to the required level, the difference in ground loads and flight loads could cause significant changes in the local deflection of walls, shafts, seals, or bearing retaining housings. Such deflections could cause wear and stress in locations that would not be detected by visual inspection and borescoping. Furthermore, if the Preliminary Flight Certification (firing tests of a single engine) and the results of the Main Propulsion Test Article (firing three engines simulating space flight operation) are accepted as valid, then there

[1] A boroscope is an instrument, now utilizing fiber optics technology, used for illuminating and visually inspecting otherwise inacessible places.

should be no qualms about removing one engine for inspection and replacing it with a spare. After considering the three approaches, the committee still concludes that a tear-down inspection is essential and now recommends a complete tear-down inspection of one engine after the first flight and its replacement in the orbiter by a spare engine. Depending on the outcome of the tear-down inspection[1] and the results of borescoping and visual inspection after subsequent flights, the inspection procedure for the first six flights could be established.

Moreover, the committee also considers a complete disassembly and inspection of the engines to be essential after the sixth flight and supports the NASA proposal of a visual inspection, including borescoping the high-pressure turbopumps, after each of the orbital test flights. Much can be learned during the flight tests that will bear on the future development of the engine. NASA and Rocketdyne should allow for this in their planning, if they are not already doing so.

Component Test Stand

The committee, in its first report, had recommended that NASA and Rocketdyne explore means to acquire and operate a component-development test rig for the rotating machinery of the main engines. Instead, NASA and Rocketdyne have chosen to use a rocket engine itself for this purpose. To this end, test stand A-3 at Santa Suzanna, California, has been reactivated. The committee considers that this approach is far from ideal and could lead to long delays in the event of major mishap such as a failure in a high-pressure turbopump. Such a failure could result during tests to explore the functional limits of components, including the "red-line" limits for operational safety, because the engine is used as a test stand. Thus, if further failures occur, long delays will result unnecessarily.

An additional consideration is the possibility of an unexpected failure of a component during the operational life of the shuttle. The sustaining engineering program needed to support the shuttle may be more economically and more effectively carried out through the use of a component test stand. The committee is concerned that replacement hardware will not be available when components fail and, worse yet, spare engines will not be available for use as new test stands to replace those lost as a result of component failures.

The committee considers that it is not too late to develop a component test rig. A component test rig would be valuable not only in the testing process to extend the life of the engine to 7½ hours, but also for the sustaining engineering that is likely to prove necessary over the useful life of the shuttle. While recognizing that engines will have to be used for some time to test components, the committee urges NASA and Rocketdyne to take appropriate actions

[1]The committee understands that no contingency plan exists to cope with problems uncovered by this inspection. This is a consequence of a success-dependent program strategy.

to acquire a component-development test rig.

Oxygen Heat Exchanger

NASA and Rocketdyne have complied with the committee's recommendation to explore alternative designs to relocate or reconfigure the oxidizer heat exchanger. The heat exchanger is now in a hot, hydrogen-rich location (see Figure 1). Short of placing it in a less perilous location, there is no practical way to eliminate the threat to the total system in the event of a failure in the heat exchanger. Since March 1978, NASA and Rocketdyne have made a design study of a "line-replaceable" heat exchanger that can be more readily and thoroughly inspected in the field -- one that could be replaced and would be less subject to damage during fabrication. As designed, the new heat exchanger would be about 170 pounds heavier than the present 20-pound heat exchanger. The present program plan calls for completing the detailed design of the line-replaceable heat exchanger and holding it as a back-up until it may be needed.

While the committee concurs with the actions taken to date, it is still concerned with the present heat exchanger and reemphasizes the statement in its previous report that urges continued attention to the oxidizer heat exchanger by both NASA and Rocketdyne.

Evidence has been found that heat exchanger tubes have been rubbing against their supports during some of the engine tests. Such rubbing could lead to small holes in these tubes. With the oxygen pressure in the tubes relatively high, even a small hole will emit a jet of pure oxygen into the hydrogen-rich gas, which will result in combustion within the heat exchanger. In this event, potential is great for a disastrous explosion. It is of the utmost importance that the heat exchanger be readily accessible for routine inspections in the field. The committee recommends, therefore, that NASA and Rocketdyne move ahead with the construction and testing of the line-replaceable heat exchanger for installation in the shuttle main engine as early as practicable.

Integrity of High-Pressure Fuel Turbopump Turbine Blades

In its earlier report, the committee noted the three failures that had occurred in the high-pressure fuel turbopump turbine blades up to that time. Because such problems are common in turbine development, the committee assumes that the problems can be resolved before the Preliminary Flight Certification tests are completed. To that end, NASA and Rocketdyne have initiated an inspection program to detect and remove blades that contain cracks they consider harmful. For the longer term, however, the committee recommends that a more aggressive program be established to understand the cause of the turbine blade cracking in order to prevent it. The need exists for improved blades. This can be achieved by (i) an improved blade design, (ii) an improved alloy, (iii) a modified cast structure,

(iv) a more flaw-free material, (v) a more searching and stringent inspection system -- or some combination of these. The long range objective of improved turbine blades does not seem to have progressed in the main engine development program beyond today's state-of-the-art.

NEW CONCERNS

High-Pressure Fuel Turbopump Turbine Blades Platform Cracks

Since March 1978, no complete blade failures have occurred in the high-pressure fuel turbopump turbine. The committee is concerned, however, about the appearance of cracks in the blade platforms after very few operating cycles. The cracks may be caused by low-cycle thermal shock from the start-up and shut-down cycle. In addition, a few cracks have developed in the leading edge of some blades. When a crack is found in the leading edge of the blade, the blade is now replaced. By contrast, NASA and Rocketdyne regard platform cracks as tolerable unless these propagate into the blade. The difficulties involved in perceiving clearly how far a crack has progressed is a point of contention between the committee and NASA.

If blades with platform cracks are to be used at all, a decision to regard a crack as having grown to a dangerous size must be based on prior experience. Although such experience is not very extensive at this time, it is being accumulated. Experience in the test program to date has shown that the high-pressure fuel turbopump can be operated for at least 15 start-stop cycles of the engine without any failures in the turbine blades. After 15 start-stop cycles, the high-pressure fuel turbopump is disassembled, the turbine blades removed, the blade coatings stripped off, and any cracks carefully examined. Then a metallurgical examination is made, which includes cutting, etching, and microscopically inspecting the blades. The resulting data are being collected by Rocketdyne for a data base on all the high-pressure fuel turbopump turbines in the program. By the time of the first manned flight, it is expected that a substantial amount of data will have been acquired. The data are intended to provide confidence in the operational procedures yet to be established. The committee suggests that the data be displayed in an appropriate statistical distribution to justify with confidence the selected interval between inspections.

Still, no program now exists for the prevention of cracks in the turbine blade platforms of the high-pressure fuel turbopump. The present planning allows the use of blades with small cracks in their platforms for engines in the first manned orbital flight. Such a

procedure is contrary to current, conventional practice. Thus, the results of future tests must prove that such platform cracks will not result in actual or incipient failures of the blades. Therefore, effective inspection measures must be used after each cycle of operation, definite limits to crack size must be defined, and limits on rate of growth must be established. Every effort must be made to establish a technical and statistical basis justifying the use of blades with platform cracks in early flights.

The committee understands that NASA's Marshall Space Flight Center has initiated a full-scale fracture mechanics program to determine the rate these cracks grow and the inspection interval needed to ensure that no crack-induced failure occurs between inspections. The Marshall program is intended to complement the Rocketdyne program. If this fracture mechanics program is fully successful, the committee deems the inspection intervals will be well defined prior to the first flight. In any event, the committee recommends that NASA prepare and document detailed procedures for determining crack growth rates and develop statistical data to justify its confidence in this matter.

High-Pressure Fuel Turbopump Turbine Blades Coating

Rocketdyne is conducting a relatively extensive program to find a satisfactory coating for the high-pressure fuel turbopump turbine blades. The program was undertaken initially to develop a reliable coating to enable the blades to tolerate thermal spikes, which are high gas temperatures for very short periods, that occurred during the early engine tests. Since then, thermal spikes have been greatly reduced. The stated justification for coating the blades was to suppress thermal shock stresses generated in start-stop operation. The committee considers that the need for coatings is questionable and that sometimes they are the cause of problems. For example, if the coating is not well bonded to the blade material, it will spall or peel, causing turbine wheel unbalance and vibration. If the coating is well bonded, cracks in the coating can propagate into the blade material.

Since the original need for coating the high-pressure fuel turbopump turbine blades seems to have been eliminated, any expected benefit from coating seems to be questionable. Therefore, the committee recommends that test runs with uncoated blades be included in the test program. If the results support the hypothesis that coating is not warranted, the use of a coating should be discontinued.

Low-Pressure Fuel Turbopump Turbine Bearing Fretting

During the course of tests, fretting of the turbine end-bearing has been observed in the low-pressure fuel turbopump. Fretting is usually indicative of inadequate bearing retention, which permits relative movement between the bearing and its journal or housing. Under such circumstances, fretting cannot be alleviated by dry

lubrication. The relative motion needs to be reduced by proper bearing retention. This will involve a redesign of this part of the low-pressure fuel turbopump. The committee, therefore, recommends that the turbine bearing retention system on the low-pressure fuel turbopump be redesigned to reduce the relative motion between the bearing and its journal or housing.

Main Injector Oxidizer Post Shields

In early summer of 1978, a number of failures occurred in the oxidizer posts in the main injector of engines 0002 and 0005. Design modifications have been made to prevent such failures from recurring. The oxidizer posts (see Figure 1) carry oxygen internally through the main injector to the combustion chamber. An array of these posts separates the oxygen from the hot, hydrogen-rich gas, which flows around, and impinges on, the posts at high pressure and relatively high velocity. Thread-cracking in the posts has been attributed to vibration in bending. The cause of the failures is postulated to be fluid mechanical forces. These failures allow oxygen to leak and mix with the fuel, leading to premature burning. Once this happens, failures occur in adjacent posts.

To remedy this problem, steel shields have been installed on adjacent pairs of the oxidizer posts in the outer ring of posts -- i.e., those first encountered by the incoming hot gas. The function of the shields, according to NASA, is to protect the first row of posts from the incoming flow and to break up high-frequency oscillations in the wake of the posts -- thus reducing the vibratory loads and stresses in the threads. Subsequent tests have shown the shields to be effective in eliminating the pressure oscillations and reducing the loads in the posts. To date, tests have demonstrated a lifetime for the shields and posts in excess of 5,000 seconds. Calculations indicate that the shields will outlast the projected 7½-hour lifetime of the engine. The modification to the main injector has increased the weight of the engine about 13 pounds. A major part of the increase is due to the addition of 42 oxidizer post shields.

Of concern to the committee is the measured increase in the turbine inlet temperature of the high-pressure fuel turbopump at rated power level after the post shields were installed. The higher temperature is caused by the increased power required to overcome the pressure loss when the flow is restricted by the shields. Consequently, the committee recommends for the intermediate term that a study be undertaken to identify and eliminate the source of the unsteady flow at the first row of posts. Rocketdyne has proposed a new post design and material (Haynes-188) intended to resolve the problem of the injector post failures without the use of the shields, thereby eliminating the resulting temperature increase in the high-pressure fuel turbopump turbine inlet. This has not yet been tested.

Flight Certification

The engine development program includes a Preliminary Flight Certification that consists of a set of ground tests on a single engine. The purpose of these tests is to certify the engine configuration for use in the first six orbital flights.

In its initial report, the committee made certain recommendations with respect to the minimum test requirements for Preliminary Flight Certification that should be fulfilled in tests on a single "flight-configured engine" before the first manned orbital flight. NASA and Rocketdyne now propose Preliminary Flight Certification test requirements that are essentially in agreement with and, in some aspects, more stringent than the committee's recommendation. The proposed requirements call for an accumulation of 5,000 seconds of engine test time, including at least 3,000 seconds at rated power level and 425 seconds at 102 percent rated power level, as well as one aborted-flight simulation involving either abort-to-orbit (665 seconds at rated power level) or abort with return-to-launch-site (823 seconds at rated power level). The committee endorses this set of Preliminary Flight Certification requirements as an adequate demonstration of the engine's performance and reliability for the first manned orbital flight.

However, the committee is concerned that because of design changes, the engines to be used in the orbital flight tests are not exactly the same configuration as the engine to be tested in the Preliminary Flight Certification. The differences are significant. While the committee continues to recommend the use of a "flight-configured engine" for the Preliminary Flight Certification tests, it concludes that the Certification, as presently scheduled, is premature. The committee recommends that currently planned testing continue but that the formal Preliminary Flight Certification be delayed until the configuration of the engine to be certified is the same as the actual flight engines in all respects affecting safety.

The Preliminary Flight Certification should be viewed as a formal event. If there are any configuration differences, NASA, Rocketdyne, and in particular the Material Review Board and the NASA Aerospace Safety Advisory Panel should agree in advance on the acceptability of the configuration to be certified. Similarly, if any changes are made during Preliminary Flight Certification testing, the acceptability should be redetermined by the same groups.

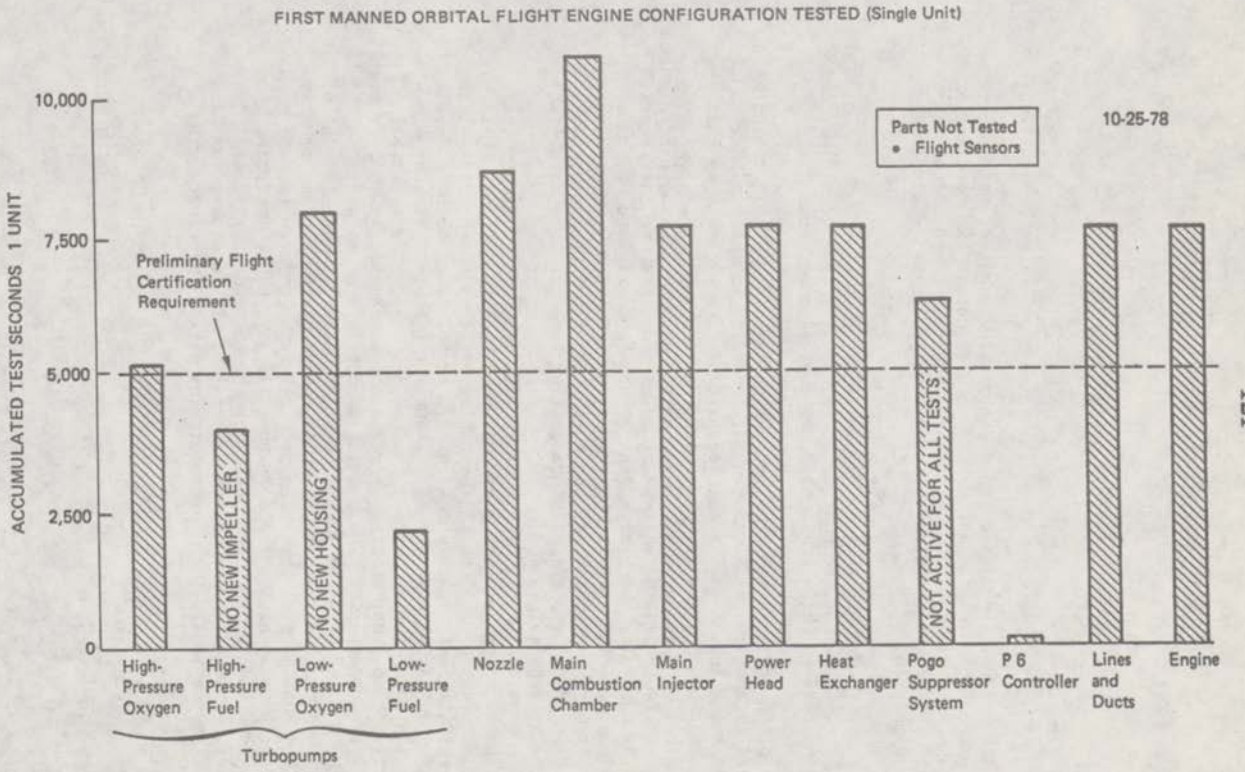
Component Test Requirements for Orbital Flight Tests

It has been standard practice for manned space flights using expendable launch vehicles that the engines be subjected to ground tests for at least ten times the duration of the actual flight. This testing protocol has provided an adequate margin to account for variations from engine to engine and for unforeseen events that might occur in flight. By contrast, the shuttle engine, unlike previous

manned space propulsion systems, is designed to be reused in subsequent launches after inspection and, if necessary, repair and refurbishment. Therefore, the committee considers it unnecessarily stringent to require engine ground testing amounting to ten times the flight duration for the space shuttle main engine for flights after the first. In the committee's judgment, the performance and reliability of all components in the flight engine should be demonstrated by ground tests for a life of at least three times the use such a component will encounter in the six orbital flight tests.

Because the total engine-on flight time for the orbital flight test program is about 3,000 seconds (520 seconds per flight), the committee recommends that, insofar as practicable, all components of the engine be tested to the point where single components have each accumulated at least 10,000 seconds (see Figure 3). One way to accomplish this objective is to continue testing the engine used in the Preliminary Flight Certification tests toward the goal of 10,000 seconds. Alternatively, designated components could be run on research and development engines until the 10,000-second goal is attained for each component. Because it seems likely that some minor components, whose replacement is not a matter of concern, will not survive these tests, a list of components that could be replaced without risk to the program needs to be agreed upon in advance by appropriate NASA review groups and by Rocketdyne.

Should any engine component fail to attain the objective of 10,000 seconds, the committee recommends that it be replaced in the engine during the orbital flight test program but not to be flown for more than 30 percent of the successfully accomplished test time for the component. It is recommended that any exception to this procedure be approved at the highest level of NASA.



SOURCE: Rocketdyne Division Rockwell International

FIGURE 3

RECENT ACCIDENTS

In December 1978, two main engines experienced damaging malfunctions while being tested at the National Space Technology Laboratories at Bay St. Louis, Mississippi. After NASA and Rocketdyne had examined the engines and evaluated the failures, they reported their findings to the committee.

Engine 0007

During the first checkout test for the preflight certification of engine 0007 on December 5, 1978, an explosion occurred in the heat exchanger at 3.5 seconds of the planned run of 50 seconds. The source of the failure was attributed to a leak in the coil tubing of the heat exchanger, which was caused, according to the explanation, by a weakness in the tubing that occurred during arc welding while an adjacent bracket was reworked with the heat exchanger still in the engine. The weakness went undetected because existing procedures did not call for a detailed inspection or proof-test of the reworked part. As a result, the heat exchanger and high-pressure oxygen turbopump, both integral to the engine, were damaged -- though these and other major components of the engine are considered reusable. Inspection procedures and pressure testing have now been established for similar repairs.

The committee recognizes the description of the cause of the explosion as a possible order of events but points out that there are two other ways the failure in the tubing could have occurred -- i.e., very high internal pressure caused by a restriction, such as debris, in the tubing or slow growth of a flaw in the tubing. In any event, the committee recommends that NASA and Rocketdyne establish inspections and proof testing or rebalance procedures as appropriate for all reworked parts. The paucity of development hardware in the program, coupled with the ambitious test schedule, makes the use of refurbished parts a certainty. While the practice of using reworked parts and subcomponents provides valuable experience in the development of an engine for a 7½-hour life cycle, it increases the chance for flaws or malfunctions, with the consequent risk of failures. Therefore, the committee considers it necessary for NASA and Rocketdyne to develop appropriate inspection procedures with a

sense of urgency. Because the committee considers a failure in any part of the oxygen system to be potentially catastrophic, the accident in Engine 0007 reinforces the committee's concern, expressed in its first report, about a single-point failure in the heat exchanger.

Engine 2001

Engine 2001 had passed the acceptance test in January 1978 and completed four Main Propulsion Test Article runs between April and July 1978 -- accumulating a total of 287 seconds of test time. After this series of tests, the engine was returned to Rocketdyne for a turbopump retrofit. Then, during the third of a new series of acceptance tests, at 255.6 seconds of its test run, fire broke out in the main oxidizer valve, leading to extensive damage to the engine and the A-1 test stand. The failure was caused by a sequence of events: pressure oscillation in the oxygen flow led to vibrations in the main oxidizer valve inlet sleeve, which were sufficient to loosen one of eight retainer screws and allow fretting between metal parts; this resulted in enough friction to heat the metal to its ignition point in pure oxygen.

Actions to avoid fretting in the future include replacing the thin metal shims with ground shims, coating the surfaces with an oxygen-compatible dry lubricant,[1] and replacing the cap screws with screws with a conical shoulder, and providing conical seats incorporating a locking device. The committee supports the need for remedial changes.

In the design goals of compactness and lightness in the closely coupled main shuttle engine, vibrations of fluid-mechanical origin may occur. This provides considerable potential for rubbing or fretting. The committee recommends, therefore, that all fasteners should be examined for loosening and wherever feasible all means of eliminating such loosening should be incorporated.

Rocketdyne has initiated an investigation into the source of the vibrations in the main oxidizer valve and potential remedies. The committee considers further investigation into this problem to be important to pursue.

This episode underscores the earlier finding by the committee that parts and components need to be tested individually before they are assembled and tested as an engine system. If the main oxidizer valve had been mounted in a test stand so that its compliance could have been the same as in the engine assembly and tested, the vibration and fretting might have been identified early in the test program.

One of the effects of both incidents is to highlight the shortage of spare parts and components -- not only to ensure that the test and development program can be completed on a reasonably early schedule

[1] During a discussion of dry lubricants, the committee concluded that more study is needed to make a convincing case that dry lubricants can be used safely.

but to provide enough hardware for the manned flight tests and later operational missions. The situation appears more critical now than at the time of the committee's last review.

In a previous section of this report, the committee has noted that replacement parts and additional engines to be used as test stands will be needed to advance the progress of the program in the event of malfunctions and accidents. To ignore this in a development program as highly complex as this one is to take inescapable risks. Therefore, the committee urges that a plan be drawn up and carried out as quickly as possible to provide additional replacement parts and engines for the space shuttle main engine program.

SCHEDULE CONCERNS

Some components or parts of the engine to be tested for Preliminary Flight Certification are new relative to the configurations used in the research and development engines previously tested. Incorporating previously untested components in an engine designated for certification is considered unusual and is disturbing to the committee. This procedure would reduce the probability of success of the Preliminary Flight Certification. The existence of any components with very little test time, such as the P-6 engine controller and the new impellor for the high-pressure fuel turbopump, leads the committee inexorably to the conclusion that an early Preliminary Flight Certification is unlikely. Any failure (not necessarily catastrophic) will lead to program delays. This is particularly true because of the existing shortage of development engines, spare parts, and test stands. These shortages undermine the expectation for an early manned orbital flight. In view of this, it appears unlikely that the first manned orbital flight will occur before April or May 1980. The first manned flight could be somewhat earlier only if the engine testing program encounters minimal or no difficulties--an improbability, considering the previous test history of the shuttle main engine.

Once the recommended tests are completed in a satisfactory way, the committee is confident the main engines will perform safely for the first manned orbital flight.

SUMMARY OF RECOMMENDATIONS

A. With respect to the first manned orbital flight, the committee recommends that:

- o No significant differences should exist in the shuttle main engine that NASA intends to certify and the one it intends to fly. The formal Preliminary Flight Certification should be delayed until an engine of flight configuration is available for testing.
- o NASA and Rocketdyne should prepare a detailed technical case for the method for determining platform crack growth rates, the intervals and procedures of inspection, and the criteria for the replacement of turbine blades in the high-pressure fuel turbopump. The case should explain the rationale and demonstrate that engine operation with some platform cracks is not harmful.
- o One engine should be removed from the shuttle orbiter following the first flight and a complete tear down and inspection performed for signs of wear or stress.

B. For later in the manned orbital flight program, the committee recommends that:

- o An agreed upon list of engine components should be tested to the point where individual components have each accumulated 10,000 seconds of test time before the sixth orbital flight. The test time is to be accumulated on a schedule that maintains about 3:1 ratio between total time in ground tests and total time in flight on any single component or assembly.

C. For the longer term in the shuttle flight program, the committee recommends that:

- A plan to acquire additional engine test and development hardware should be prepared and implemented in the program as soon as possible.

- Appropriate actions should be taken to acquire a component-development test rig as early as possible, not only for use in the engine development but for use in the sustaining engineering program when the shuttle becomes operational.

- The turbine bearing retention system on the low-pressure fuel turbopump should be redesigned to reduce any relative motion or fretting between the bearing and its journal or housing, eliminating the need for dry film lubrication.

- Tests of the high-pressure fuel turbopump should take place with uncoated turbine blades, and if test results indicate that a coating is not warranted, its use should be discontinued.

- A program should be established to gain an understanding of the source of platform cracks in the high-pressure fuel turbopump turbine blades -- a program designed to lead to crack prevention.

- An aggressive program should be undertaken to gain an understanding of the cracking of the high-pressure fuel turbopump turbine blades in order to prevent its occurrence.

- A study should be undertaken to define the primary cause of the oxidizer injector post failure to provide a "fix" without the need for shields, thus eliminating the source of increased turbine inlet temperature in the high-pressure fuel turbopump.

- The design, development, construction, and testing of an alternative high-pressure oxygen turbopump should continue in order to be ready to be installed in the engines by 1983 or 1984.

- A line-replaceable heat exchanger should be constructed and tested for installation in the shuttle main engines as early as practicable.

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The Covert Report on the technical status of the engine came to the conclusion that because of existing shortages of developmental engine spare parts and test stands, it appears unlikely that the first manned orbital flight will occur before April or May, 1980.

Now, I understand the reluctance on the part of NASA to give much ground on the schedule, but I think that you stated that there is only 10 to 20 percent chance of launching by the current date of November 9, 1979. Is that correct?

Dr. FROSCH. That is correct.

Mr. BOLAND. In view of the recent Covert Committee Report on the engine, which indicated that there is only a 50–50 chance of launching by a year from this May, haven't we reached a point where you ought to set a realistic date then try to live with that? Doesn't the Agency suffer from a problem of credibility with respect to its launches?

Dr. FROSCH. We are squeezed between two problems. There is no question that by setting a success-oriented but possible schedule, and then resetting it, we suffer from a problem of the external perception of what we are doing. On the other hand, our concern, based on our experience in running a variety of programs, is that if we set a date that is later than the possible date, that date then becomes the first possible date. That situation is simply the nature of R&D programs of this type. If you set a date that has some slack in it, that slack will be eaten up and then becomes, not the most probable date, but the earliest date.

Therefore, as a matter of maintaining what we consider the internal discipline of running the program, we like to keep an early but possible date as the official one, and simply suffer the external problem because, while damaging to NASA, it is less damaging to the program. Perhaps John Yardley would like to add to that.

Mr. BOLAND. John, what is your best bet now as far as the launch schedule?

Mr. YARDLEY. I agree completely with what Dr. Frosch said. In fact, in terms of the testimony before the Senate authorization subcommittee, when Dr. Covert gave his findings, I was asked to comment on it. He admitted that if he were doing our job, he would continue the schedule as we had. It is a matter of tactics. Now, practically, the end of December is possible. I think there is probably a 40 percent chance by December.

Dr. FROSCH. I have been saying a 50 percent chance.

Mr. YARDLEY. What I see is that January is more probable.

POSSIBLE CAUSES OF SHUTTLE DELAYS

Mr. BOLAND. Have the delays been occasioned more by funding restraints or by technological problems?

Mr. YARDLEY. I will give you my opinion on that. I think you hit on the two main reasons for delay. The engine work has not been hampered by lack of funds, although the Covert Committee people say it has been because five years ago we didn't plan a program that allowed for a lot of extra hardware. The fact is that we have not held up testing at all for lack of hardware or for a lack of testing capability. They just feel uncomfortable because they don't see a lot of engine hardware sitting on the shelf in case something happens.

The Shuttle funds have also been a constraint in this sense. The rest of the program was a bigger job than we thought five years ago. With regard to Fiscal Year 1978, for example, as you recall we came to you and said that we needed to transfer some production funds into development because we could see at that time that we had underestimated development. We got halfway through the year and we needed more funds for development. At the end of Fiscal Year 1978 we had to lay off people to get out of the year without overspending. We deferred about $80 to $100 million worth of Fiscal Year 1978 work into 1979 and that caused problems. We didn't want to ask for more money when, at the same time, the engine was having difficulty. If we speeded up the program and the engine didn't make it, it would have been wasted.

In all, I think the cost problem has about balanced the technical problems.

Mr. BOLAND. Let me read to you from the final House Appropriations Surveys and Investigations Report published last April on the Space Shuttle Program.

"Most of the engine test time has been limited to short duration runs at relatively low power. In an attempt to build up experience in engine run time at rated power level to satisfy the requirements for the first manned orbital flight, it should be expected that additional engine problems may surface which would cause additional delays. Due to the extreme shortage of hardware in the SSME Development Program an engine failure would result in a shutdown of one to three months."

That was written last April. Will you agree that turned out to be fairly accurate?

Mr. YARDLEY. I would like to comment on that. It is true that we had additional engine failures. Dr. Frosch mentioned three major failures. But we didn't suspend engine testing because we didn't have enough hardware. The reason why we suspended the testing was that we had to find solutions to the problems and implement them. We had ten major engine failures in the program, but only one engine has been nonrepairable. The rest of them have been overhauled.

Mr. BOLAND. Do you expect any additional problems?

Mr. YARDLEY. If you put that in the context of additional major problems, I would have to say I hope not. But we could never be completely free of that possibility until we get twice as much engine test time accumulated.

Dr. FROSCH. Mr. Chairman, I think there is an important point to be made about the difference between this year, at this time, and last year with regard to the engine. I would characterize last year by saying that the engine mostly didn't run, and when it did it was a very interesting event. Now we are in the situation where the engine mostly runs, and when it doesn't, it is a very interesting and important event. I think we have had enough test runs and enough full-duration runs, and even longer than normal full-duration runs, to demonstrate that basically the engine operates and can be made to operate. The question now is building up the test time so that we have confidence that we can begin to understand what the long lifetime problems are. I think we have good confidence that the run durations for OFT flights are going to be achieved fairly shortly. The question is how near are we to achieving 55 flights with the engine? We are probably

a fair way from that, but that doesn't interfere with the early test and operational schedule.

Mr. BOLAND. Lindy, do you have any questions or comments?

Mrs. BOGGS. I am very delighted to have the opportunity to congratulate you on the Jupiter successes. We are unanimously proud, as all Americans are, of you. Also, I think it is the most perfect timing that I have ever heard of for an agency to be able to have such a success right in the face of asking for their appropriations.

Dr. FROSCH. One of the advantages of orbital mechanics is that they dictate when events happen.

HARDWARE SUPPLY FOR ORBITER FLIGHT TESTS

Mrs. BOGGS. In quoting from the Covert Report to which the Chairman has already alluded,

"One of the effects of both incidents is to highlight the shortage of spare parts and components—not only to insure the test and development program can be completed on a reasonably early schedule, but to provide enough hardware for the manned flight tests and late operational missions. The situation appears more critical now than at the time of the Committee's last review."

If that language sounds strikingly familiar to the language contained in the Appropriation Committee's Investigative Report, I guess the only conclusion we can come to is that the extreme shortage of spare parts has been due to the lack of sufficient funds requested for the program. Is that a fair assumption?

Dr. FROSCH. I would like to ask Mr. Yardley if he would comment on that.

Mr. YARDLEY. Dr. Covert, when he made his initial report last spring, similar in kind to the report of the Committee's investigative group, recommended that we provide additional test capability. Consistent with that recommendation, we took funds earmarked for other things at that time, and we activated an existing R&D single-engine test stand at Santa Susana. This capability combined with the two test stands available at NSTL, provided three stands. In addition, as recommended by the Covert Committee, we accelerated the delivery of the three engines for the second flight orbiter (099) to be closer to the first flight orbiter so that we would have more hardware available to us. Those efforts take a long time to do. We started to work on activation of the Santa Susana test stand in April, and we started testing in November. The first of the accelerated engines will be available about a year from now. There is about a three-year leadtime cycle to obtain new hardware not in the pipeline. There is no way to improve the hardware situation in a short period of time. So we did what we could.

As I said earlier, we have not actually been paced by the lack of engine hardware. We have only lost one engine due to major test failure. We have eight full R&D engines, with a lot of pumps and other hardware.

We have, it is fair to say, been running the program as tightly as we can in funding, but this has not turned out to be a delaying factor in the engines up to this point.

Some of the accelerations, I might add, are part of the reason for the supplemental request. When we accelerated the efforts on those engines for earlier deliveries, it mean more funds in Fiscal Year 1979.

Mrs. Boggs. That was what we were going to lead into next.

ESTIMATES OF DELAY COSTS

Mrs. Boggs. Last year when the Fiscal Year 1979 budget was transmitted to the Congress it included a three month delay in the initial operational date of the Shuttle—from June, 1980 to August, 1980. The DDT&E cost increased approximately by $210 million. The FY 1980 budget assumes an additional six month delay in the first manned orbital flight, roughly from June, 1979 to November or December, 1979, and a six month delay in operational capability, from August, 1980 to February, 1981. Those delays will cost the program an additional $224 million. Are these costs expressed in 1971 dollars? What is the real year dollar cost of the delays that have just been discussed?

Dr. Frosch. I would like to ask Bill Lilly if he would comment on that.

Mr. Lilly. Yes, Mrs. Boggs, they are expressed in 1971 dollars. The amount, combining those two numbers, in real year dollars, is around $800 million.

Mrs. Boggs. Thank you very much. I know you want to be as upbeat as possible, Dr. Frosch, about the Shuttle, but I thought I would make an observation that this program will cost us $15.2 billion in 1980 dollars. Everytime we have a delay that cost goes up another $200 or $300 or $400 million. That has never made much sense to us. With that large of an investment, spending a little additional money two or three years ago, even last year, would have ultimately saved NASA and the taxpayers hundreds of millions of dollars. I recognize it is easier to second guess but I believe we could have waited a little longer on the large Space Telescope and have spent that $500 million on the Shuttle to insure that it would fly on time and save the Government a good deal of money.

Dr. Frosch. I think the situation has been that we have been paced more by technological problems than by money problems. Money can help, but frequently we have not known exactly where we would put the additional money until we had the next problem. It is difficult to say whether putting that much money into the program would, in fact, have kept the schedule on its original basis. I think we generally agree that it would not; that the kind of technological problems we are having simply take time to overcome. While we might have saved some time by preventing the kind of situation that John Yardley described a few moments ago—namely having to use money from one part of the program in another—it would not really have prevented the time loss that comes from technical difficulties that were not anticipated.

Mrs. Boggs. We did provide a $95 million supplemental a couple of years ago.

Dr. Frosch. Most of that helped production.

Mr. Yardley. There was $95 million additional provided in the Economic Stimulus Appropriations Act, 1977, most of which was to initiate production activities.

Mrs. Boggs. Mr. Stewart, I hope you will cut in at any time you wish to, or would you like to ask some questions now?

Mr. Stewart. You folks are spending too much money here. You are talking about millions like they are quarters; I have to sort of catch up with you gradually. [Laughter.]

Mrs. Boggs. All money well spent.

If, as the Covert Report suggests, there is an additional six month delay for the first manned orbital flight to May 1980, what is the cost of such a delay expressed in both 1971 dollars and real year dollars?

Dr. Frosch. Mr. Lilly, do you want to address that?

Mr. Lilly. Mrs. Boggs, you would have to make certain assumptions as to what caused the problem, but let me make an assumption that it would be the current type of engine problem as the most likely cause. If that were the case, it is our estimate that it would probably increase the Fiscal Year 1980 Shuttle DDT&E costs by between $75 and $100 million. You would have to, in order to do that, delay production funding in Fiscal Year 1980 by that same amount, and pick up the increased total costs in 1981 and 1982. Our estimate is that the total increased Shuttle cost would be around $350 to $400 million in real year dollars, and in 1971 dollars that would equate to probably on the order of $200 million.

COMPONENT DEVELOPMENT TESTING

Mrs. Boggs. Thank you very much. The Covert Report indicates that NASA, in building the main engine, must rely on a "success-dependent" strategy. The report notes that that type of strategy is a departure from traditional procedures of development stages in that component development testing was foreshortened and the quantity of spare parts was severely limited. The problem with this approach as outlined by the Covert Committee is that when malfunctions occur during the testing of the prototype of the operational engine, new hardware may need to be designed, constructed, and retrofitted, resulting in delays. The Report states that that is what happened. Do you agree with that assessment, and if not, why not?

Dr. Frosch. I think that we feel that the problem has not been spare parts, but perhaps John Yardley would like to comment.

Mr. Yardley. The Covert Committee took us to task for not doing enough component testing in the early phases of the program. It is not fair to assume that we started out without a component test plan and decided to just test the whole engine. That was indeed not the case; they didn't have time to get into all the details, but we actually spent at least $25 million building a component test facility at Santa Susana. We tried to test components and did test some components, but it was a very slow, painful process. We had one major failure of an oxygen pump in that component test facility. That was the facility's fault and it was put out of commission for six months. We have never put our full engine testing out of commission for more than a month.

This Shuttle engine operates at four times the pressure of previous engines. When we started building a component test facility for that, it meant we were really into a complex development. We had to simu-

late all the other parts of the engine with all the big pipes, plumbing, and tanks that are required for each component. It is very costly, so we concluded it is cheaper to use the engine itself as a test facility. As I said, while there have been ten major failures, none of the delays have been because of test stands or spare parts. The holdup was always finding out what was wrong and fixing it, and you have to do that, whether you have got hundreds of parts or tens of parts. In that respect, we don't entirely agree with the Committee.

PRELIMINARY FLIGHT CERTIFICATION

Mrs. BOGGS. They also zeroed in on the question of preliminary flight certification. The Report points out its concern that, because of design changes, the engines to be used in the orbital flight test are not exactly the same configuration as the engine to be tested in preliminary flight certification. The Report states that differences are significant. It further recommends that currently planned testing continue but that the formal preliminary flight certification be delayed until the configuration of the engine to be certified is the same as the actual flight engines in all respects affecting safety. What is your reaction to that recommendation? Do you plan to implement it, and if you do, what would be its effect on the initial launch date?

Dr. FROSCH. I will start by commenting that we had some internal discussion before the Covert Report about that question of how identical the certification engine needs to be to the flight engine before we have the requisite confidence in its safety and performance. I think we are still looking at the question of exactly how close the two have to be. John, would you like to comment?

Mr. YARDLEY. Yes. The actual engine that we have at NSTL was one of the three planned for flight, and it is currently identical. There is no difference. The Covert worry is about any additional changes between now and flight. We certainly acknowledge that if there are changes made after we have certified, those changes have to be individually certified. With respect to the detailed configurations of the engines, when you run an engine on an R&D test stand, you have to have certain connections that are different, certain minor transducers to test its limitations, and that sort of thing, that are not in a flight engine. I have reviewed, in a preliminary way, these detailed differences and there is only one difference that one could argue about. That is an accelerometer package for flight use which is not currently available. Therefore, we are using accelerometer packages with similar accelerometers, which are suitable for flight test purposes. They would be essentially qualified, but Dr. Lovelace has asked that we have a review with him next week to go over all of these details prior to our first certification firing.

Dr. FROSCH. I would only add that before we as the management of the Agency will be willing to allow the first flight to be conducted, we will need to convince ourselves that we have indeed tested as nearly as is possible to do, what is to be flown and demonstrate that it will be safe. That is the fundamental pacing item. In fact, the real answer to the question, "When will we have a first flight?" is that we will have a first flight when we are fully convinced that we are prepared and ready for a safe one.

EFFECTS OF FY 1979 SUPPLEMENTAL ON SHUTTLE PROGRAM

Mr. BOLAND. As you said in your remarks, you are requesting a supplemental of $185 million for the Space Shuttle Program. You further indicated what the impact on the program would be in terms of the first manned orbital launch schedule if the supplemental is not available until October 1, rather than July 1. Do you want to expand upon that? You noted that the overall impact of failure to receive the requested supplemental is estimated at being in excess of a billion dollars. You may break that out for the record, if you will, though. I would be interested in how you break out the detail for the first sentence, "We have estimated the failure to receive a supplemental funding for Fiscal Year 1979 would increase total Shuttle program costs by $400 to $600 million." And then, "The purchase of additional expendable launch vehicles would be required of us." So that is an additional expenditure. You also state, "Another major area of impact, more difficult to define, would involve the loss of payload benefits due to optimization for the STS launches." Please expand on this for the record.

[The information follows:]

Cost impacts are estimated to exceed $1 billion if the FY 1979 Supplemental Appropriation of $185 million is not approved for Space Shuttle. Unavailability of the $185 million to meet Space Shuttle program requirements would cause major program impacts increasing the total cost of the development and production currently projected for the Space Shuttle program and increasing costs in related NASA program activities and among users of Shuttle launch services. These cost impacts are summarized as follows:

Without the supplemental it has been estimated that the first manned orbital flight would be delayed four to six months with an increase in total development costs of from $300 to $400 million, and that the follow-on orbiter deliveries would be delayed from 6 to 12 months at cost penalties of $100 to $200 million.

In addition to this $400 to $600 million impact in direct program funding, the Shuttle schedule delays would result in other budget and programmatic impacts, particularly to payload users. Currently planned STS missions on the Shuttle will have to be rescheduled, where possible, to expendable launch vehicles. This would necessitate the purchase of additional expendable launch vehicles at considerable additional cost to all users estimated at approximately $400 million.

Another area of cost impact, but more difficult to quantify accurately, is the cost of delay to those users whose payloads remain on the Shuttle and who may incur additional costs of schedule stretch-outs in payload preparation and, in some cases, loss of revenue from delay in payload operation. Potentially these costs, including the costs of delaying Spacelab missions, could be more than $200 million. One specific payload effect to NASA involves the Tracking and Data Relay Satellite System (TDRSS). Under provisions of the NASA contract with Western Union, NASA will pay for the services of TDRSS over a ten year period beginning when the system becomes operational. The basis for charges for the service include the contractor's cost for development and investment in the system with an appropriate allowance for interest and fee. Delay of the launch will increase the cost to NASA of the TDRSS services and will also delay the planned closing of tracking stations. Increased costs to NASA resulting from a six month delay in Shuttle availability is estimated at approximately $60 million.

In addition to the above cost impacts, a delay in completion of Shuttle development, test and evaluation will result in an extension of the time during which it will be necessary to continue some related development and supporting activities. NASA development activity related to Spacelab and Upper Stages, for example, will be extended, as will activities at NASA centers supporting Shuttle development and test. The additional costs in these areas are estimated at approximately $100 million.

In summary, the full cost impact outside the Shuttle direct program is difficult to assess accurately and to define specifically, but our analysis indicates that potential cost increases of $700–$800 million would occur and would affect all Shuttle users with the U.S. Government absorbing nearly 60% of the increase

and foreign and domestic commercial interests absorbing about 20% each. When these related cost impacts are combined with the estimated direct program cost penalties, the overall impact of not obtaining the supplemental appropriation is estimated to exceed $1 billion plus the effects of future inflation.

Mr. BOLAND. George Low, who is no stranger to this Subcommittee, said at the recent meeting of the American Institute of Aeronautics and Astronautics that,

A rational space policy then becomes a mutual outgrowth from a clearly stated purpose and goal. In terms of content, there is no alternative other than a central element, which is a permanent manned orbital platform, leading to continuous human beneficial occupancy of space.

Does that run contrary to Dr. Press's thinking, and perhaps the President's goal?

Dr. FROSCH. Yes, I think it does. I have not discussed that subject with George Low and I am not sure why he chooses that single goal as the only one which can provide a central goal. In fact, I am not really quite sure why he is so certain that we must have a single central goal. My feeling is that we are already at a point in the maturity of the use of space where we have a variety of activities to do, and that a single central goal is not really required for the momentum of the program.

Mr. BOLAND. What about the "Shuttle funding wedge?" What does that mean?

Dr. FROSCH. I think that if one assumes that NASA were to have a fairly level total budget year by year, then as we go into 1980 and beyond, the funding required for the development and production of the Space Transportation System decreases rapidly. Some of that decrease is taken up by operational costs, and some by maintenance engineering and developmental engineering. But taking that into account, there would be money available in a total level budget by virtue of the fact that the Shuttle program would be decreasing. That is described as the "wedge," because if you draw a flat overall budget curve and a decreasing Shuttle curve, then you have a wedge-shaped piece in the outyear budgets. The question is, "What happens to that money?" If NASA maintains a level budget, that funding becomes available for space science, for space applications, for aeronautics and space technology, and for the development of further technology. I think one of the policy and budgetary issues over the next several years will be how much of that wedge remains in NASA, and is applied to other parts of the space program, and how much of it vanishes from the NASA budget and is used either in the Federal budgeting process or simply becomes a decrease in the total Federal budget.

Mr. BOLAND. I suppose, in view of these projections on the constrained budget, there isn't going to be much room left in the 1981 or 1982 for the Shuttle funding wedge?

Dr. FROSCH. If the total budget projections that have been made are, in fact, the future budgets, then in the FY 1981 budget there would be slightly less than $200 million left after the runout of current programs that is available for some new work. In FY 1982, there would be slightly less than $500 million for some work, assuming that our estimates of the runout of the current programs are correct.

Mr. BOLAND. There are no new flight starts projected in the 1980 budget; were any requested?

Dr. FROSCH. Yes, there were a number of major new flight starts requested.

Mr. BOLAND. Would you list them for the record? Were they requested for Fiscal Year 1980 or were they candidates for funding in Fiscal Year 1981?

Dr. FROSCH. A number of them were requested for Fiscal Year 1980.

[The information follows:]

The following are the proposed new flight projects that were recommended to OMB, but were not included in the FY 1980 budget request:

Gamma Ray Observatory—A mission to conduct a comprehensive whole sky survey in this highest energy radiation region of the electromagnetic spectrum. Gamma rays are produced by the most fundamental physical forces powering the universe. Investigations of these processes would advance our understanding of the origin of elements, and the nature and dynamics of such powerful energy phenomena as quasars, pulsars, and black holes.

Venus Orbiting Imaging Radar—A mission to extend our knowledge of comparative planetary by global mapping of the previously unobserved surface of Venus, by measuring its gravity field, and by studying the composition, structure and dynamics of its dense, cloud-shrouded atmosphere. These investigations would increase our understanding of the similarities and differences among the planets and contribute to knowledge about the processes that influence the Earth's environment.

National Oceanic Satellite System (NOSS)—A cooperative effort, in conjunction with the Department of Commerce's National Oceanic and Atmospheric Administration and the Department of Defense, to demonstrate a limited operational capability for a space-based ocean observing system to meet the needs of civil and defense users. The NOSS would provide a global data acquisition and data management system, capable of obtaining information on ocean features and conditions such as wind speeds, sea surface states, ice cap profiles, and cloud and rain patterns.

SUBMISSION TO OMB

Mr. MCDADE. Dr. Frosch, I am interested in your last statement. Would you tell me the total dollar differential between what you requested and what you were given?

Dr. FROSCH. The dollar differential was $208 million.

Mr. MCDADE. $208 million?

Dr. FROSCH. Yes, sir.

Mr. MCDADE. We found in some other subcommittees that there were serious arguments over priorities between the agency and OMB. In other words, an agency goes in with priorities one, two, and three, but comes out the other door of OMB with a different set of priorities. I am interested in knowing whether that happened in your case. Did NASA have any of its top priorities scrubbed by OMB?

Dr. FROSCH. We did not have any major rearrangements of priorities, as I recall. The closest thing we had to that was in some cases we did not get what we described as the "current level." In the ZBB process one goes in with the minimum possible level, the current level and enhancement levels. There were some areas in which we got less than the current level, but I don't recall that any of these were very major.

Mr. BOLAND. So this $208 million we are talking about is spread out over quite a few areas?

Dr. FROSCH. Yes, it is spread over about 15 areas.

Mr. MCDADE. In no instance did the Office of Management and Budget totally substitute its judgment for that of NASA's?

Dr. FROSCH. No, but we have had some fair arguments about relatively small items.

Mr. McDade. Okay, so it is a question of funding levels, as you indicated.

Dr. Frosch. Basically, right.

Mr. McDade. Thank you, Mr. Chairman.

Mr. Boland. You have insisted that you couldn't use any extra money two or three years ago. Is that correct?

Mr. Yardley. What I said was that if we had it, we would have been able to use it, but the part of the program that hasn't had the technical difficulties would have gotten ahead of the engine. It happens that our lack of immediate funds has about kept pace with our problems on the engine.

Mr. Boland. Do you recall the supplemental of three years ago, in the Jobs Bill, where we provided $95 million?

Dr. Frosch. Most of it was to initiate production in FY 1977 rather than as increased development funding. Consistent with the Committee's action, $70 million provided for initiation of production and $25 million was applied to DDT&E in FY 1977. I would like to add that shortly after that, in FY 1978, we reallocated FY 1978 production funds into development.

Mr. Boland. The reason I raise this is it would seem, if the request had been made for additional funds in years gone by, and if we had supplied the funding, then we would be saving more money this year. That is one of the problems I think we have. If we fail to provide the supplemental, we are going to be faced with a loss of about a billion dollars ultimately. It is not going to be an easy task to convince other Members of Congress to provide the funding because some of those Members responsible for getting the bills to the House floor, and the leadership, particularly in the House Budget Committee, are very concerned about the supplementals. We are fast approaching the Budget Resolution ceiling and will go beyond it if we try to make provisions for NASA's supplemental needs. But, in any event, there is going to be considerable opposition to supplementals. So we face the problem of providing $185 million and convincing the House that this is going to be a real saving and that failure to do it is going to cost the program, in the long run, $400 to $600 million as well as additional increases in other areas.

That is why we are concerned about the position of this Committee in being certain that we are going to provide sufficient funds to NASA to run the programs the way they ought to be run.

POSSIBLE USAGE OF ADDITIONAL FUNDING

So I ask you, Dr. Frosch, if additional funds—$50, $75, $100 million extra—were provided would you be willing to give us a list of priorities where they might be spent?

Dr. Frosch. Certainly. We would be happy to give you such a list.

Mr. Boland. This is not to say we are going to do it.

Dr. Frosch. I understand.

[The information follows:]

Possible Application of Additional FY 1980 Funds

In response to your question, if additional funding were made available for currently authorized NASA projects and activities, the primary emphasis would be placed on additional assurance that the Space Shuttle is brought

to operational capability as efficiently and effectively as possible. The Shuttle's flexibility and economy of operations are a necessity for expanding the uses of space and for maintaining U.S. leadership in space applications, sciences, and technology. Another area of emphasis, therefore, would focus on Applications and Science project definition studies and advanced technical development activities to enhance our readiness for important next-step flight projects. Similarly, Advanced Programs study and evaluation efforts would be augmented to provide a basis for exploiting the considerable capabilities of the Nation's Space Transportation System. In Aeronautics, focused technology efforts in advanced rotorcraft would merit consideration, particularly in view of the growing demand and competition in the world helicopter marketplace. In Facilities, additional funding could be productively used for further energy-conservation modifications. Across-the-board, Research and Technology activities, which are the wellspring of advances in both aeronautics and space, would be strengthened.

As you requested, a prioritized list of these areas of emphasis is provided below.

Space Shuttle design, development, test and evaluation $50,000,000

To provide additional flexibility for meeting unanticipated problems during the critical orbital flight test period. Some of the previously planned contingency has been impacted by problems in main engine testing and thermal protection system installation encountered after the preparation of the budget.

Space Shuttle follow-on orbiter fabrication $15,000,000

To increase the efficiency of the fabrication flow consistent with activities initiated in fiscal year 1979, including items common to both a four and five orbiter fleet.

SPACE APPLICATIONS AND SPACE SCIENCE

Project definition and advanced technical development for new flight project candidates such as:

National Oceanic Satellite System $4,000,000

To strengthen the definition and engineering activity for potential initiation of this satellite system in fiscal year 1981, as part of a cooperative program with the Department of Commerce (National Oceanic and Atmospheric Administration) and the Department of Defense.

Multispectral resources sampler $2,000,000

To initiate development of an advanced flight sensor for Earth observations.

Space science—new project preparation $8,000,000

To enhance project definition activities and advanced technical development efforts in preparation for initiating development, in fiscal year 1981, of the Venus Orbiting Imaging Radar mission or a cometery mission using solar electric propulsion, and the Gamma Ray Observatory.

Space transportation systems—advanced programs $5,000,000

To provide additional depth in studies and advanced technology relating to areas such as a deployable antenna system; and to strengthen definition studies and evaluation efforts, in preparation for initiation in fiscal year 1981 of a solar electric propulsion stage for cometary and other high energy missions and a 25 kilowatt power system for extending the in-orbit stay-time of the Shuttle.

Aeronautics—advanced rotorcraft technology $5,000,000

To provide for focused technology activities in key areas such as areo-acoustic design and methodology, vibration reduction, flight control and avionics systems, and engine component design.

Energy conservation $8,000,000

To provide for six facility modification projects in order to achieve major reductions in energy consumption. These projects are cost-effective, with simple payback period of less than 4.5 years, and are important in NASA's plan for continued reductions in energy consumption at its installations.

Research and technology $12,000,000

To enhance supporting research and technology and data analysis activities in order to increase the effective use of data required from previous and current missions and to strengthen the basis for important next-step activities in future years.

Mr. BOLAND. I think it is something we ought to examine.

Dr. FROSCH. I think what we have been saying is this: If additional funds had been provided earlier, they would have done useful work, and, in parts of the Shuttle program, would have saved us from some later funding problems of larger size. But they would not have kept the total Shuttle flight program on schedule because that has been paced by the technical problems in the engine. So we would be in a position where some of the efforts that we need to spend supplemental money on this year would have been accomplished previously, but those things having been completed would then be waiting for completion of engine testing for the first flight.

Mr. BOLAND. Mr. McDade, any general questions?

Mr. MCDADE. Your statement to the Committee, I notice, doesn't talk about the impending descent of Skylab sometime in July. When is that approximately?

Dr. FROSCH. That is about our best prediction now—June or July.

Mr. MCDADE. Is there anything you would like to tell us to update or educate the Committee about the present status of Skylab?

Dr. FROSCH. Only that we have put Skylab into an attitude which has the best chance of keeping all of the systems operating. As you may recall, the systems have been decaying. We are losing charges on the batteries and having other troubles. We have put it in a position where we can keep the batteries charged as well as possible in case there turns out to be some way of gaining influence on how it reenters. It is not now certain whether we will have any possibility of influencing it.

When I say influence, I mean move the Skylab from a high drag to a low drag configuration attitude, or vice versa. That might possibly have some influence on descent orbit. This is not real control, but it might be a way of influencing it. We are by no means certain that we can do that. We are trying to figure it out.

What we have done is prepare for the remote contingencies of damage. We are prepared to do whatever can be done in that case. The probability of damage is still extremely small. Our current best predictions on reentry are June or July, and we continue to monitor it on a continuous basis.

Mr. MCDADE. You mean the probabilities of damage are low because you anticipate a water landing?

Dr. FROSCH. Both because it will most probably be over water and because the density of the pieces that come to the ground is rather low. As one looks at the predicted density of pieces and compares it with previous experience, both with space debris reentry and with meteorites, the results of those statistical comparisons say that the probabilities are extremely low.

Nonetheless, we will be prepared for a serious contingency even though we think it is highly improbable.

Mr. MCDADE. I hope your statistics are right. Thank you, Mr. Chairman.

Mrs. BOGGS. Mr. Chairman, last year there were two things that we touched upon that I would like you to comment on this year, Dr.

Frosch. Could you expand on the search and rescue demonstration project that is a joint project with Canada, France, and the U.S.S.R. as it progresses toward the 1982 flight?

Dr. FROSCH. Yes, as you recall, the idea of the program is to put receivers and transmitters on certain satellites so that they can receive and retransmit signals from emergency beacons. Then that information can be received and processed for the beacon's location. We are still proceeding on that program. We have had recent discussions with both France and Canada as well as with the Soviet Union. It looks as if all parties are coming onboard the program nicely, and I think it is fair to say it is still on schedule.

Dr. CALIO. Yes, it is.

Dr. FROSCH. Perhaps Dr. Calio would like to comment further.

Dr. CALIO. As you know, we are modifying the operational NOAA satellites to install those processors for the emergency beacons. The modification is underway. The Canadians are building the receivers, and the French are building the processors to go onboard the spacecraft. It still looks like it is on schedule.

The United States is also developing the local user terminal for the United States, and the Canadians are developing it for Canada. That work is progressing very, very well.

Mrs. BOGGS. Do we have the capability to put them to use before 1982 if we had more money to do it with?

Dr. CALIO. No, that would be very difficult. The reason is that the satellites being modified are NOAA's operational meteorological satellites, and the time of the start of the demonstration really depends upon the call-up of a particular satellite. We are modifying the one that they expect to call up in 1982. To make that modification, we have to go far enough down the line of production to pick one that we could modify and not impact the operational requirement, and yet early enough that it would bring us the demonstration within a reasonable timeframe. Additional funds right now could not help us accelerate our schedule.

Mrs. BOGGS. It is such an important program, and I congratulate you on pushing it along as rapidly as you possibly can.

In the area of materials processing, emphasis is now on research and experimentation. I remember last year we questioned why you weren't manufacturing materials in space. You say you have now identified 14 areas of investigation for early Shuttle missions such as crystal growth, containerless processing, and fluid dynamics. In addition, you are looking for possibilities of joint ventures between private industry and NASA. Could you expand on that please?

Dr. FROSCH. Yes. The question as to why do we not manufacture something is really a question of what we should manufacture. The work done to-date really points us principally in the direction of research into the question of what is manufacturable, and what the scientific results are that would show what can be done. So that is the principle approach that we adopted. We are preparing for Spacelab missions particularly, that will allow us to carry out the scientific experiments that will establish the basis for sensible manufacturing.

However, there are one or two areas where enough has been done so that there is some real commercial interest in participating in the research program, with the hope that it would move very rapidly from

scientific capability to a real industrial capability. There are two or three industrial firms sufficiently interested so that we are now, in the negotiation stage, trying to understand the legal and business arrangements that would make it possible for both the Government and the industrial firms to participate in the research program and still satisfy both the public and private requirements for who owns the data, who owns the patents, who has the right to carry things beyond that.

One of those firms is involved in biochemical manufacturing, and the other, as I recall, is in the manufacturing of latex microspheres. Those are tiny spheres that are used as standards in various kinds of industrial work, such as standards for electron microscopy and other areas. It turns out that there is a size range of such spheres that cannot be satisfactorily manufactured in a one-G environment simply because of the sedimentation and the convection problems. There is a belief that these spheres could be manufactured in a zero-G or nearly zero-G environment. They fit the requirements for a space product because there is a need for a relatively small quantity of raw material to produce them, and small quantities of the product can be made. They would be extremely valuable. So, there is commercial interest in doing it.

Mrs. BOGGS. Almost like a Swiss watch?

Dr. FROSCH. Yes.

Mrs. BOGGS. Dr. Jenkins, I do know that you have the hiring restrictions of the Leach Amendment to reduce your manpower. Of course, it is very difficult to have your hiring practices examined in the light of the restricted personnel staffing ceiling, but I would like to ask what NASA's equal opportunity objectives are in the promotion of women and minorities and the training of women and minorities? What percentage do you have in upper-level managerial posts? If you would like, provide that for the record.

Dr. JENKINS. Yes, we will do that.

[The information follows:]

As of 12/31/78, nearly a quarter (24.6% or 5703) of NASA's overall permanent workforce were minorities and women. They comprised 13.9% or 2076 of the professional workforce and 9.0% or 1032 of the scientists and engineers. There were 192 or 4.0% minorities and women at the GS 14–16 level and 18 or 4.8% in Excepted positions. There has been modest but steady progress in the increase of minorities and women in the workforce since the end of FY 1974 when minorities and women represented 21.1% of the overall permanent workforce, 9.2% of the professional workforce, 6.2% of the scientists and engineers, 2.7% of the GS–14–16 level and 2.5% of the Excepted positions.

This record has been accomplished by an aggressive goal of 40% for minority and female professional hires and a 35% goal for minority non-professional hires.

During FY 1978, minorities received 18.3% of all promotions, a proportion greater than the 8.3% of total permanent strength represented by this group at the start of the fiscal year. The promotion rate for women was 36.7% of all promotions, basically twice their 18.4 percentage availability at the start of the fiscal year.

During FY 1978, 31.6% of all employees participating in training were minorities and women. Of special training programs, minorities and women were 15.5% of the participants in the Executive Development Program; 5.4% of those in the Supervisory Development Training Program; 79.9% of those in the Continuing Education Program (CEP I) where college courses are taken after duty hours at NASA's expense; 97.4% of those in the Continuing Education Program (CEP II) where college courses are taken during duty hours at NASA's expense.

Of the formal upward mobility programs, minorities and women were 100% of the participants in the Growth Opportunity (GO) Program which provides an opportunity for reassignment from non-professional to para-professional positions; and 94.7% of the participants in the Speciality Training for Entry Professionals (STEP) Program, which provides an opportunity for non-professional employees to enter specified professional positions. In addition, minorities and women were 64.5% of the participants in other types of upward mobility programs.

Of all employees changing from non-professional to professional positions during FY 1978, 76 or 67.7% were minorities and women.

Dr. JENKINS. I would like to comment that our promotions of minorities and women are at least comparable to their percent of the occupations and grade levels from which the promotion would be made. We have done very well in the promotions of our employees. We have also done very well in involving them in training programs, including upward mobility programs, as well as programs for mid-level and upper-level management. As a result, we feel that we do have an aggressive program, as well as a good hiring program.

We will submit some statistics for you showing the various levels. We currently have 18 minorities and women in our excepted ranks, and increasing numbers at GS–13, 14 and 15.

Mrs. BOGGS. Thank you very much. I would like particularly to know the percentage of the people who are in clerical positions but have had the opportunity for promotions.

Dr. JENKINS. Yes. We will give you the number of non-professionals and professionals.

Mrs. BOGGS. Thank you very much.

Dr. JENKINS. I hope you have had an opportunity to meet some of our women astronaut trainees.

Mrs. BOGGS. Yes, I did. I had a very nice opportunity to do so. I am very interested in them and in all of the astronauts. Thank you, Mr. Chairman.

Mr. BOLAND. Thank you.

Mr. STEWART. Mr. Chairman, in this budget estimate book on page RD 7–4, under Resource Observations, it says,

"This program addresses needs for information of vital economic value to the United States and of importance to global humanitarian concerns, such as the world's food and energy supplies."

Doctor Frosch, could you elaborate on this in more detail and cite specific examples of what you have been able to accomplish in this area?

Dr. FROSCH. I think the best agricultural example is the result of LACIE—the Large Area Crop Inventory Experiment—on which we are now building a global program. We were able to demonstrate over three years, working with the Department of Agriculture and with the Department of Commerce, that by using space remote sensing data with agricultural models and weather data, we could take an inventory and, in fact, predict with good accuracy for the end of the growing season what the wheat harvest for certain areas was going to be. This is more information on global wheat than we have ever had before, and it gives us the possibility of understanding the world food situation in a much better way than ever before.

This is a technology which is in some ways of least interest to the U.S. domestically because we have so good an agricultural statistical system. But most of the world's countries do not; they do not even know how much wheat they have grown even at harvest time.

Therefore, building on this LACIE experiment, we believe we can undertake a program which will result in a means of assisting the Food and Agriculture Organization of the United Nations and the world food organizations to get better estimates of world food production. That will enable them to do a better planning job for the management of that food on the international scene.

As another example, we have been working with the Government of Bangladesh, which has a severe problem in understanding how the floods, both from the ocean and from the rivers, affect the land in the river deltas. They literally have been in a position where they cannot inventory their farmland, which has changed as a result of some severe flooding. By using this data, they are able to do mapping and find out where the available new farmland is and where previously available farmland has been destroyed.

We have just begun to work with the United Nations' environment program on the question of the spread of deserts. In particular, the Sahara is well known to be spreading south in some places at a rate which has to be measured in miles per year. But the details of where this happens are not known. We now have a capability for following this pattern year-by-year so that one can understand considerably more about the management of the bordering land, which is not quite desert, in terms of preventing that spread from happening.

There are similar activities, such as the study of rangeland management in East Africa. There is a whole collection of international uses of the data, and that is building up continually. A good deal of our ability to do that is based on successful uses of the data inside the United States, where we have a great many programs with States and localities.

Mr. STEWART. In a report entitled "United States Civilian Space Program: An Overview" which was prepared by the Congressional Research Service, it is stated that although there has been only a little cooperation with the Soviet Union, such cooperation is significant because the United States and USSR are traditionally rivals rather than partners in space exploration. What type of cooperation exists now between the United States and Russia in the space program, and what are the possibilities for future cooperation?

Dr. FROSCH. The principal areas of cooperation have been in space science. The most successful continuing one has been in biological experiments in space, where we have had a cooperative program in which we have supplied experiments that have been flown on Soviet spacecraft. They have been flying a series of biology satellites. We have not, but we have some very good technology for experiments in this area. We have been supplying the experiments. They, in turn, have been flying the experiments and supplying us with returned experiments—because they bring some of them back—and with data from them. We have been mutually trading all the information we get in those programs.

We have also been discussing a number of space science and exploration programs with them. The most recent exchange of data has been

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in the Venus explorations, which both sides carried out at the end of 1978. We have exchanged preliminary data and information and expect to trade results in considerable detail later.

We think the prospects for scientific cooperation are quite good. Another example is the Search and Rescue Experiment Project, which was mentioned previously. We expect the Soviet Union to join France, Canada and the U.S. in doing that task.

Mr. STEWART. Thank you, Mr. Chairman.

Mr. BOLAND. What about the charge that the Space Shuttle is overweight, overcost, and behind schedule? We know it is behind schedule; the first manned orbital flight was originally planned to take place in March, 1978. So, there is no doubt about that, it is behind schedule. What about overweight and overcost?

Dr. FROSCH. We estimate that, in 1971 dollars, the development cost of the Shuttle will be about 10 percent above our original estimate of March, 1972. As now projected, compared to that original estimate of $5.15 billion, in 1971 dollars, the Shuttle development would be about $5.65 billion.

With regard to overweight, there is no question that the system is short of its proposed cargo carrying capability by what, John?

Mr. YARDLEY. Right now without the thrust augmentation, but after we do our weight savings plans, it will be about 1,500 pounds short of capacity for East Coast launches and about 8,000 pounds short for West Coast launches.

Dr. FROSCH. To remedy this, we do have a plan and there is some funding requested in the 1980 budget to study further how we can recover this by increasing the thrust.

Mr. BOLAND. We stand adjourned until 10 o'clock tomorrow morning when we will look at Research and Development.

Dr. FROSCH. Thank you, Mr. Chairman.

WEDNESDAY, MARCH 7, 1979.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. BOLAND. The Committee will come to order. Let me see if we can clarify some of the testimony from yesterday. I think you made the point that although you could use more money in the Shuttle program, in no case would that have helped improve the schedule. You also indicated that spare parts have never been a problem in the engine. The last point is particularly troublesome to us because the recent Covert Committee Report clearly indicated that the engine was starved for spare parts; our own Surveys and Investigations staff came to the same conclusion about the lack of spares; and three Rocketdyne officials advised the staff that spares were a problem. Now, who is right?

HARDWARE SUPPLY AND SHUTTLE SCHEDULE

Dr. FROSCH. I would like to comment about the first part and try to clarify this question about whether more money would have changed the schedule. I believe we said that more money would have advanced some parts of the production and the development activities more than they are now, but it would not have controlled the schedule because what really has controlled the schedule is the technical problems with

the engine. If we had had more money, we would be farther ahead on other elements of the program, but we would still be schedule-dependent on what happens with the engine, which is probably the pacing item controlling the first orbital flight. At the moment, it is actually nip and tuck between the engine and the tiles, but the engine is probably the critical factor.

Mr. BOLAND. Do you agree with that?

Mr. YARDLEY. Yes, sir. I would like to clarify the engine testing situation. My point was that, given the test stands we had and the testing we have done, we have not been held up by lack of parts.

Mr. BOLAND. You have not been held up by lack of parts?

Mr. YARDLEY. Not by lack of parts. Perhaps we should have provided twice as many test stands to start with, and tested twice as many engines. I am not saying that that approach wouldn't have gotten us farther down the road. But we did not take that approach six or seven years ago, and, given the decisions that were made, we had ample hardware to keep the testing moving.

Dr. LOVELACE. I might add that even having activated the third test stand at the recommendation of the Covert Committee, none of the test stands have been starved for lack of spares or hardware.

Dr. FROSCH. We may now wish that we had another test stand and more engines to test on it. However, last year or even the year before, we could not have a test stand ready for this purpose in less than three or four years. The feeling was that there would be no sense in putting money into another test stand at that point in time, since it would presumably come along after we had finished the bulk of the engine testing.

Mr. BOLAND. You never requested any additional funds?

Dr. FROSCH. We never requested any because it didn't look at any point as though it would help the problem.

Mr. YARDLEY. At this particular time, Mr. Chairman, we have five engines in development, another three for main propulsion testing, three flight engines, and a spare which will be out in several months. We have engines on all of our single-engine test stands, and we have two recently overhauled engines standing by, ready to go if there are problems. Lack of hardware is not holding us back.

Dr. FROSCH. I would like to make one other comment. It may be out of order because I was not at NASA at the time. But I can easily see that in setting the size of the program and the size of the test program, there was a feeling that the number of tests to be done on the engine should be scaled to a size that would not be perceived as overblown or over done. It would have been hard to justify at the beginning of the program as being necessary. Maybe it was skinnied down a little too much in the perfect hindsight that we now have, but I think if one had said there were going to be six test stands or five test stands, we would have had trouble at that time explaining why we were putting so much money into that testing without suggesting that there were problems that nobody foresaw.

Mr. LILLY. If I may add one comment, Mr. Chairman, as you remember, we planned to initiate the development of the main engine a year ahead of the actual approval of the Shuttle development because of the long lead-time on the engine; however, as soon as we made a selection

and contracted to start, we had a protest. Resolution of the protest held us up for almost nine months, and I don't think we have ever really caught up with that delay on the engine.

Mr. YARDLEY. If you look at previous space project developments, twice as many test stands were traditional with much more hardware. The Shuttle development was an attempt to do a very complex technological task with a lower funding level. The first main engine is the first reusable engine ever developed. We thought that we would be able to reuse these engines even after failures, and I think this approach has pretty well paid off because we have only lost one total engine and scrapped another one during the entire test program.

SHUTTLE DEVELOPMENT

Mr. BOLAND. I think you have had some fine answers to our concerns.

We will turn to RD 1–1. The table on that page shows that you are requesting $1,366,000,000 for continued development of the Shuttle compared to $1,628,300,000 in the current estimate column for 1979, which includes the supplemental request of $185,000,000. You have updated for the Committee the tables appearing in the final investigative report on the Shuttle system. These tables deal with the total Space Transportation System investment and the total cost of the system, to both DOD and NASA. In FY 1980 dollars, it comes to approximately $15.2 billion. Of that amount, $11.6 billion is funded through NASA. Including the $1,366,000,000 requested in FY 1980, how far are we along the road of funding that $11.6 billion total for NASA?

Mr. LILLY. Mr. Chairman, I would want to put the exact number into the record. It is approximately $8 billion through FY 1979.

[The information follows:]

The current projection of the NASA investment in the Space Transportation System is $11.6 billion in dollars of the FY 1980 budget. Including the applicable estimates in NASA's FY 1980 budget request to the Congress, the cumulative funding against the $1.6 billion total will be approximately $9.5 billion.

CURRENT MISSION MODEL

Mr. BOLAND. The current mission model is 487 flights carrying approximately 1,000 payloads. That is on page 14 of the Investigative Report. Of those 1,000 payloads, roughly one half, or 495, are projected for NASA. Of those 495—389 are planned as Spacelab payloads. Is there enough money in the 1980 budget, which has no new flight starts projected, or in the OMB planning level for 1981 and 1982 to fund the planned NASA payloads for the first five years of the mission model?

Dr. FROSCH. Yes, there is for the mission model as it was projected in the Investigative Report. But what is happening to the early phases of the model is that we now have actual manifests for the first three years—two years in addition to the year of orbital flight tests. We have fitted actual payloads into that. I don't know whether it matches the mission model. I think it is the case that some NASA payloads have been crowded out by some commercial payloads. Isn't that right?

Mr. YARDLEY. I don't have the precise answer, but we have more commercial payloads than the model predicted for the first several

years. In addition, since the schedule slipped, in any given early year we have fewer flights than the model.

Mr. BOLAND. Is one of the reasons you don't have as many NASA payloads that you don't have the money?

Dr. FROSCH. At this point, it is basically that the schedule does not really permit anymore NASA payloads than we have put into the first two years of the manifest. With regard to Spacelab, we have had some internal discussions—not centering solely on money, but including money questions—as to the right balance between the use of Spacelab and the use of free flyers for certain scientific missions. These discussions involved money in the sense of having the right balance of funds between using Spacelab and free flyers. One of the considerations is what it may cost to use Spacelab and whether those costs will hold or will grow. The approach that we are considering is eventually to allocate a certain amount of funding annually to Spacelab missions and fly Spacelab as often as that funding allows. We would use other funding for free flyers. We would follow that type of approach, at least in the early years, until we understand the operation of Spacelab better than we do in our projections now.

I do not think we are changing the NASA programming of Shuttle missions at this point because of the budget factors. There are other factors that are forcing change.

I have the actual flight schedule numbers and the mission model. Through 1984, the NASA total in the mission model was projected to be 27 flights. In the actual schedule we are now working, it is projected to be 28 flights. The extra flight, by the way, appears in calendar year 1981, early in the operations. The calendar years 1982, 1983, and 1984 numbers are 7, 8, and 11 for NASA, both in the mission model and the flight schedule.

The reimbursable missions for that period are up by three flights, from 42 to 45. Therefore, the total for the current flight schedule is up to 73, compared to the mission model of 72. The difference is the additional NASA flight. What has happened with the reimbursables is that whereas we had scheduled three reflights in that four year period, we have now absorbed those into the schedule of reimbursable flights.

So things are beginning to move around, and at least for the first four years of operational flights the numbers are about the same although the details may be changing. The whole model has stretched out.

PROJECTED SPACELAB FLIGHTS

Mr. BOLAND. In the Investigative Report, on page 15, there is a table which explains how the 487 mission model flights would be flown. It indicates that the mission model includes six Spacelab flights in Fiscal Year 1981 and eight Spacelab flights in Fiscal Year 1982. That model was updated last August and it now indicates one Spacelab flight in 1981 and five in 1982. Is that the current traffic model?

Mr. YARDLEY. My information is four; one in 1981 and four in 1982.

Dr. LOVELACE. Yes, I think we do carry one in 1981 and four in 1982.

Mr. BOLAND. Are there sufficient funds in the 1980 budget to fly the four Spacelab flights in Fiscal Year 1982?

Dr. FROSCH. Yes, for the Fiscal Year 1980 part of that requirement.

Mr. BOLAND. How much funding will be required for the nine flights in 1983? You have nine planned for 1983, do you not?

Mr. YARDLEY. Yes, sir.

Mr. BOLAND. How much will be required to fly those nine flights in 1983?

Mr. LILLY. The estimated funding for the Spacelab payloads, Mr. Chairman, is $101 million in FY 1980, $107 million in FY 1981, $136 million in FY 1982, and $143 million in FY 1983, which includes the applicable funding for those nine flights.

Mr. BOLAND. I take it that there are enough funds in the Fiscal Year 1981 and 1982 OMB planning estimates to fly the four flights in 1982 and the nine flights in 1983, correct?

Dr. FROSCH. Yes, but we derived the numbers that I mentioned yesterday as available for new efforts by running out all of the currently planned programs into those two years. There is enough and that leaves some funds for starting new programs.

Mr. YARDLEY. Let me make one observation. Three of those nine Spacelab flights in 1983 are funded by either the Germans or the European Space Agency.

Mr. BOLAND. As you understand, what we are trying to establish is that the payload estimate of 1,000 for the 487 mission model represents, at this point, only numbers on a sheet. Unless there are enough funds in the NASA request for Fiscal Years 1980, 1981, and 1982, there is no possibility of flying the current payload mission model. That is the reason why we are pressing the point at this time.

Dr. FROSCH. I think the answer is that for the first several years of the traffic model and of the flight manifest, everything is holding together very well for the projected schedule. We are going to have to watch this year by year, to assure that the funding is consistent with the flights planned.

Mr. BOLAND. Let me ask the question in another way. How many new starts are required in the Fiscal Years 1980, 1981, and 1982 budgets and what budget authority is required to support the NASA share of the current payload model? You may supply that information for the record if you want.

Dr. FROSCH. We will be glad to provide that information for the record, Mr. Chairman.

[The information follows:]

Question. How many new starts are required in the fiscal year 1980, 1981 and 1982 budgets and what budget authority is required to support the NASA share of the payload model?

Answer. The answer to this question depends on a number of assumptions. For purposes of this response, we have assumed that the FY 1979 supplemental appropriation request and the FY 1980 budget request are fully supported; that the shuttle development and operational schedules are met; that the estimated funding requirements for currently approved programs do not change; that an appropriate adjustment to the FY 1981 and 1982 planning estimates is made to account for the effects of inflation; that the distribution of user payloads in the model remains essentially as currently projected; and that the payload developments initiated would come from those currently under consideration in the NASA planning process.

Under these assumptions, no new payload development projects are required in FY 1980, but it would be necessary in FY 1981 and 1982 to initiate payload development effort leading to a total of approximately thirteen (13) NASA pay-

loads. Depending on the specific payloads selected for development, budget authority requirements over and above the amount needed for ongoing programs would be in the range of $150–175 million in FY 1981 and $450–500 million in FY 1982. The amounts included for program adjustments and new starts within the OMB planning estimates for FY 1981 and 1982 are $194 million and $496 million respectively. On this basis, with the assumptions stated above, it would be possible to initiate the necessary payload activity within the OMB planning estimates.

Obviously, if the Space Shuttle development schedule slips, more funds would be required for the shuttle and less for new payloads. On the other hand, if more funds are required for other ongoing projects and to provide reasonable new activity in other program areas, such as aeronautics and space research and technology, some upward adjustment of the planning estimates would be necessary. Taking all of the uncertainties into account, we conclude that the planning estimates are a reasonable base from which to consider the desirability and priority of adjustments at the time actual budget decisions are necessary.

FIFTH SHUTTLE ORBITER

Mr. BOLAND. Last year we got into a discussion over the need for a fifth shuttle orbiter. The Committee was convinced that we should keep alive the option of another orbiter, so we included $4 million for long-lead hardware purchases. Can you indicate now in detail exactly what that money is being used to purchase? What equipment are you buying?

Mr. YARDLEY. Yes, we are planning to purchase long-lead items which can either be available for a fifth orbiter or be put to use as spares for the four-orbiter fleet if a fifth orbiter is not procured. Examples are hydraulic actuators, electronics, star trackers, and those kinds of items.

Mr. BOLAND. Based on the list that you are reading from, is the $4 million sufficient to purchase the long-lead articles?

Mr. YARDLEY. The $4 million was all that was needed for Fiscal Year 1979 to keep that option open.

Mr. BOLAND. What about Fiscal Year 1980? We want to keep the option open. How much do you need for Fiscal Year 1980 to purchase long-lead items?

Mr. YARDLEY. Our current estimate is $27 million in FY 1980. That is lower than we said we would need last year and the reason is that we have a slip in the schedule.

Mr. BOLAND. Is this a good investment?

Dr. FROSCH. We did not recommend funds for a fifth orbiter in our Fiscal Year 1980 budget request to OMB. I think it is important to keep that option open. We did not try to get money specifically in the Fiscal Year 1980 budget to hold the option because the final decision on a reasonable production line does not have to be made. Since we cannot prove that the mission model we have projected for the future will require more than four orbiters, and given the austerity of the budget, it seemed unreasonable to argue the case. If I were to predict on the basis of what has happened with previous major improvements in technology, it will probably turn out that we have underestimated the requirements rather than overestimated them. Several years from now, even if we don't have any problems or lose an orbiter, we will probably wish we had a fifth orbiter and possibly more.

Mr. BOLAND. If you come back in two years and find out that the requirements have been underestimated, you can tip your hat to the Committee for having put in the fifth orbiter.

If you were sitting on this side of the table, would you provide the $27 million for spare parts and additional hardware for the fifth orbiter?

Dr. FROSCH. Your question involves many variables in the Committee's considerations that I don't know about; but I expect I would be inclined to look at it. However, I admit I would have to do so without being able to prove that it was required.

Mr. BOLAND. I am sure that you must have previously addressed this point with the Legislative Committee and they must have been impressed because they have authorized the $27 million for Fiscal Year 1980.

Dr. FROSCH. The $27 million for Fiscal Year 1980 is the amount that would be required to proceed on a fifth orbiter. To keep a minimum option would be about $15 million.

Mr. YARDLEY. I might add that if you put nothing into this budget, the capability to start will still be open for Fiscal Year 1981. The problem is that it gets more expensive. We are not foregoing the option; it is just that we start later.

Mr. BOLAND. We would like to avoid that if at all possible. Would it be fair to conclude that if this is an austere budget—you have said so and all the agencies we have heard so far have indicated that the budgets of their agencies are lean and austere—and if the budget continues to be lean and austere in the future and the payload model is not as heavy as thought, then the requirement for the fifth orbiter will be dropped?

Dr. FROSCH. It is certainly possible to starve the program so that it doesn't require the assets. That might or might not affect the reimbursable part of the business or the DOD part of the business. One of the concerns is that if future NASA budgets became too lean, we would end up being an Agency running a Space Transportation System for outside customers, more than doing the basic research. This is a concern that has crossed our minds.

Mr. BOLAND. With respect to whether the fifth orbiter is clearly a top priority, I suppose it would be fair to conclude that this is largely a self-fulfilling prophecy in that OMB can make a better case for four orbiters if they hold back the money for the payloads. Is that correct?

Dr. FROSCH. That is correct.

Mr. BOLAND. I noticed that the Assistant Secretary of the Air Force, John J. Martin, said in testimony before the House Science Committee that we should preserve the option for a fifth orbiter.

Dr. FROSCH. In terms of our conversations with Air Force people, we have discussion about this program very frequently. I would say that their level of interest in the use of the Space Transportation System is rising rapidly. Now that it looks as if this system is really going to be available, and that they are going to have the use of its capabilities, DOD is really thinking of the many ways it would be useful. I think we are going to face an increase in demand over that demand which the Defense Department has projected. As the managers of a National Space Transportation System, we not only have to

concern ourselves with the NASA requirements but also the whole market. We see indicators that the outside market is likely to rise.

FY 1979 SUPPLEMENTAL FUNDING

Mr. BOLAND. Let us turn to the requested supplemental of $185 million in Fiscal Year 1979. I want to go back through some numbers that should help to give us a feel for how this supplemental request was formulated. In Fiscal Year 1978, NASA borrowed $100 million from Orbiter production and transferred it to Orbiter development. That action was taken because you had committed all of your 1978 Shuttle reserve funds, and you anticipated further costs in the program in Fiscal Year 1978. NASA has been pushing forward testing requirements and other funding needs from one fiscal year to the next. How much was deferred from Fiscal Year 1978 to Fiscal Year 1979?

Mr. YARDLEY. Approximately $80 to $100 million, Mr. Chairman.

Mr. BOLAND. What was the reserve available in Fiscal Year 1979?

Mr. YARDLEY. The $80 to $100 million was deferred after we had used all the reserve. We wound up with zero reserve plus $80 to $100 million of work undone in Fiscal Year 1978. I guess the answer is that instead of $100 million, we really needed from $180 to $200 million, but we couldn't prove it at that time.

Mr. BOLAND. Does the supplemental allow you to catch up during this fiscal year, or are you actually deferring some Fiscal Year 1979 work into 1980?

Mr. YARDLEY. The supplemental is sufficient funding for us to proceed on schedule. We have already, by having schedules slip, deferred some of the work that we had planned, at this time last year, to do in 1979 and 1980. Last year we planned to make more flights in Fiscal Year 1979 than we are going to make. Those flights are now going to be in Fiscal Year 1980.

In essence, the DDT&E has been moved out six months, and we have put more funds than we were projecting last year into the FY 1980 budget for development. To that extent, we deferred some of the FY 1979 work into FY 1980. If we make our schedule, we aren't going to defer anymore DDT&E work. If we slip the schedule, then, of course, the work tied to that schedule would also slip.

Mr. BOLAND. One of the things that was of deep concern to this Committee, was, first, that NASA actually request a supplemental appropriation. Since we are committed to building this $15 billion program, it makes sense to spend some money now and save hundreds of millions of dollars that can result from delays, but, secondly, although a supplemental has been requested, it appears that your Fiscal Year 1980 request is still insufficient to support the Shuttle development program.

In fact, in our March 15th report to the Budget Committee, we noted that an additional $100 million may be required in 1980 to meet the current Shuttle schedule. Is that a fair estimate?

Mr. LILLY. Is the $100 million you are referring to, Mr. Chairman, something that you added or someone else added?

Mr. BOLAND. This was in the report which we have to make to the Budget Committee, and our analysis was that it would be entirely possible that $100 million more might be required in FY 1980 to meet the current Shuttle schedule.

Dr. FROSCH. It depends on our meeting the current schedule. Assuming that we do, we expect we would be all right, but if there were any problems, they would result in a larger FY 1980 requirement. The trouble is that the amount is difficult to predict because you have to decide what kind of problem you are likely to face, where the problem might be impacted and how the program might be rebalanced.

Mr. LILLY. Mr. Chairman, if I assumed the supplemental in FY 1979 and a slip in the first manned orbital flight to the end of the first quarter of calendar year 1980, then we would have additional FY 1980 requirements in DDT&E on the order of between $75 and $100 million. If it does not slip, the FY 1980 funding would be very close. But if you asked me whether or not we would need an additional $100 million in FY 1980 I would feel a lot more comfortable if I had additional flexibility to take care of problems that we cannot predict at this point in time.

Mr. BOLAND. John Yardley would agree with that, but he will add that he won't need the $100 million because he doesn't see any slippage beyond November 9 of this year.

Mr. YARDLEY. Let me make a comment.

Mr. BOLAND. Please go ahead.

Mr. YARDLEY. I want to point out that those estimates of approximately another $100 million are right. The chances of a slip are not nil, as we discussed yesterday. There is some hedge against that, and that is in the operations budget. The start of STS operations has to slip if the first orbital flight slips. We have a substantial amount of funds in the FY 1980 budget for buying external tanks and solid rocket boosters for the early operational period. So, there is some hedge against a possible slip in terms of diverting some of those funds. As a result, we are not as vulnerable as it might seem from the standpoint of schedule and development funds.

Dr. FROSCH. If the flow is such that the first orbital flight is delayed significantly, then we would also have to delay later flights. Some of those flights would slip from FY 1980 into 1981. If that happened, some of the funds for the production of tanks and other items for those flights could be slipped from FY 1980 to 1981 and replace some of the DDT&E funds. It would be a question of exactly how the flow would go and how it is divided year-by-year in the early stages.

Mr. BOLAND. One of the problems we are concerned with is the possibility of an additional supplemental following this supplemental.

Dr. FROSCH. We very much don't want to do that.

Mr. BOLAND. Apparently one of the most serious problems that NASA has faced in Orbiter development, and undoubtedly one cause of the supplemental requirement, is the Thermal Protection System, the TPS, which is described on pages 10 and 11 of the supplemental justification. The problem of getting tiles manufactured and placed on the Orbiter has caused considerable delay.

The question I want to ask is this: Does the increasing cost of this function rest solely with NASA? In other words, are you strictly in a cost-plus situation where, regardless of what the contractor tells you he can deliver and when he can deliver it and the quality of the product, even if he doesn't meet those requirements, then NASA simply has to pay more money to get the job done?

Dr. FROSCH. That is the nature of the contract, although it does have, I believe, incentive fee provisions which could be affected in a considerable way by that. John, do you want to add any comments on the nature of the fee?

Mr. YARDLEY. It is a cost-plus-award-fee type of contract. The contractor is paid for what he actually spends to get the job done, as approved by the auditors, but the fee goes down as the overrun goes up.

Mr. BOLAND. Who is the contractor?

Mr. YARDLEY. Lockheed is the subcontractor for the manufacturing of the tiles. Rockwell, of course, is the prime contractor who buys them from Lockheed.

SPACE SHUTTLE ENGINE PROBLEMS

Mr. BOLAND. We have spoken about the engine problems that developed in December and have caused the engine testing to be suspended for about 10 weeks, and also what the cost impact of that has been on NASA's FY 1979 budget. Obviously the $185 million supplemental does not include any contingency for the significant engine explosion that took place in December. What has been the specific additional cost over and above the planned requirements, including the supplemental, for the engine delays experienced over the last two and a half months?

Mr. YARDLEY. We tried to make an evaluation of that. The direct costs of test crews who are idle and so on would amount to $7 or $8 million. The actual slip will cost something like $30 to $40 million more in FY 1979, but we can't assign the whole slip to the engine. We think the TPS status is as critical from the scheduling point of view. I would say that the total cost of slipping from September into November was on the order of $30 to $40 million. Probably the engine's share is about 60 percent of that.

EUROPEAN SPACE AGENCY NEGOTIATIONS

Mr. BOLAND. We will turn to RD 2–1, Space Flight Operations, where you are requesting $467,300,000 in Fiscal Year 1980 as compared with $309,700,000 in 1979. Turning to RD 2–3, under Space Transportation Systems Operations Capability Development, we see you are requesting $128,600,000 as compared with $109,300,000 in Fiscal Year 1979. Under that heading is a subheading, Spacelab, which begins on page RD 2–5 and is further described on page RD 2–6.

The European Space Agency is building the first Spacelab, which will consist of a pressurized module and unpressurized pallet segments which can be used in various combinations to support mission requirements. NASA is funding fabrication of the crew transfer tunnel, which will connect the crew quarters in the Shuttle cabin with the Spacelab in the payload bay. There have been some important Spacelab developments during the past year, particularly the question of the barter agreement, which, as I understand, was ultimately turned down by the European Space Agency. That agreement was offered by NASA to ESA as a substitute for the original agreement which called for NASA to purchase a complete second Spacelab from ESA.

I suspect that NASA proposed this in part because it would reduce the budget impact of purchasing the second Spacelab. Can you describe

for the Committee, in some detail, what the original agreement was, why a barter was proposed, what the advantages of the barter were, and why the Europeans ultimately rejected it?

Dr. FROSCH. Let me start with that, and I think John Yardley and Bill Lilly may fill in some of the details. Originally, in the Memorandum of Understanding the Europeans agreed to furnish the first Spacelab free, and NASA would purchase a second Spacelab. The idea behind the barter agreement was really twofold: One, as you pointed out, Mr. Chairman, it would lessen the budget impact of Spacelab procurement, particularly in these early years of high expenditures for bringing the Shuttle system to fruition, and replace it with Shuttle flights for the Europeans later in the program, where the cost would be absorbed over a period of time.

Two, there are difficulties and inconveniences in moving money from the U.S. to Europe and many complications in negotiating the contracts and having ESA as a contractor, in effect, to NASA. Some of the complications of which country would or would not accept the U.S. Government procurement regulations became very difficult. In addition, by doing the barter we would have changed the gold flow situation so that, in fact, it was not U.S. currency and gold flow going out in a direct sense, because neither party had to transfer funds.

All of these were reasons for suggesting the barter arrangement. As to why ESA rejected it, I think they could not easily figure out how to allocate the equivalent barter in a straight forward way in order to allocate the purchasing and the dollar flow into their industrial system. So they were uncertain as to how they could project the future of ESA's use of the Shuttle well enough to be willing to do that.

The current situation is that ESA has rejected the barter agreement, and we have agreed to go ahead and buy a second Spacelab at a price to be negotiated. In addition, the European contractor has made a cost proposal to ESA for a second Spacelab. The cost proposal was not satisfactory to ESA, and certainly not satisfactory to us, because it was high. But we never really had to get involved in that process. It was not satisfactory to ESA, and they are back negotiating with the contractor. We are waiting for a new proposal.

Do you want to add to that, John?

Mr. YARDLEY. Let me just add one point. One of our primary motivations was to get the Europeans to commit to the Shuttle. They have done so in spite of not having the barter. The Germans have committed to two flights and we have earnest money. Those two would have been part of the barter. ESA has tentatively said that they are going to request two Shuttle launches, which would have completed the barter, but they are not willing to put the money up yet.

I went over there with other NASA officials and spoke to the Spacelab Program Board, trying to convince them to accept the barter. I I think I would characterize the attitude of some of the countries on the barter as fine. There are other forces in ESA that want the money spent in areas other than Space Shuttle flights.

Dr. LOVELACE. The barter is difficult.

Mr. YARDLEY. ESA was going to have to commit to $160 million worth of Shuttle launches.

SECOND SPACELAB HARDWARE REQUIREMENTS

Mr. BOLAND. The 1979 budget has about $9 million in it for long-lead hardware purchasing for the second Spacelab from ESA. Isn't that correct?

Mr. YARDLEY. Yes, $8.8 million.

Mr. BOLAND. All right. Have those funds been transferred to ESA for that purpose?

Mr. YARDLEY. No, sir.

Mr. BOLAND. Why not?

Mr. YARDLEY. They are trying to persuade us to sign a letter of intent for the long-lead items. We are taking the position that we want to have at least a proposal from the prime contractor that we consider within a reasonable range before we make a commitment.

Mr. BOLAND. How much of the $58,800,000 you requested for Spacelab work in fiscal year 1980 is targeted specifically for continued hardware purchase of the second Spacelab from ESA?

Mr. YARDLEY. $34.8 million.

Mr. BOLAND. Are there sufficient funds in the Fiscal Year 1980 request to keep the second Space lab on schedule? In your judgment, are we meeting the commitment to ESA?

Mr. YARDLEY. I would say the funding we have proposed is lower than ESA feels we should have. They want to keep their contractors during the transition from development to production. The funding is adequate to meet our schedule need date for the second Spacelab. The commitment was to order the second Spacelab two years before the delivery of the first Spacelab. Theoretically, they are going to deliver the first Spacelab next fall so, we are behind on that due to the problem of getting a contract.

Dr. FROSCH. At this point, what is controlling the schedule is getting a proposal that ESA and NASA can accept. We will not see the next draft proposal until July. Isn't that right, John?

Mr. YARDLEY. Yes, July.

Dr. FROSCH. July is their schedule date for having a draft proposal ready.

Mr. BOLAND. So the first Spacelab flight, which you indicated last year would be December 1980, now has slipped to 1981. Was that slip caused by the Shuttle or by the difficulty in negotiations?

Mr. YARDLEY. It is totally due to the Shuttle schedule and the requirement that other flights must be made before the first Spacelab launch. For example, we need at least two TDRSS satellites in orbit to support the Spacelab. They have to precede the Spacelab in the launch schedule. They have certain requirements that they be separated by 90 days so that they can become operational. As a result of those considerations, the first Spacelab is planned for launch on the sixth operational flight.

PAYLOAD SPECIALISTS VERSUS MISSION SPECIALIST

Mr. BOLAND. ESA officials expressed some concern to the staff last summer that European astronauts are simply not going to get an opportunity to use Spacelab in the way it was originally designed because NASA is shifting away from the concept of payload specialists and toward the concept of using mission specialists, which are all

United States astronauts and for which the Europeans cannot apply. What about this?

Dr. FROSCH. That is not the policy change, nor was there really a policy change. What we did was look at the problem of what the payload specialists would be used for, and what the mission specialists would be used for, and we made two policy statements which are an interpretation of the previous policy.

One is that we will not fly payload specialists unless they are required for the purposes of the mission. There were some who felt that we were going to fly payload specialists whenever we flew a Spacelab mission. I think we will only fly them if they are required to perform unique tasks that require a specialized background. Many of the mission specialists have sufficient scientific and engineering training, so they could be considered when payload specialists are being selected. We are saying that they may also be among the possible candidates for payload specialists on a given mission. In fact, we would expect to fly European payload specialists when they have experiments on a Spacelab mission.

In addition, we are now considering the question of the Europeans setting up a category of permanent payload specialists. We will consider whether we would be willing to give them, on a reimbursable basis, mission specialist training so that eventually they could act as mission specialists on European reimbursable flights. I think we will agree to do that if all the appropriate arrangements can be made.

Mr. BOLAND. There is no thrust towards forming an elite group of astronauts, is there?

Dr. FROSCH. The thrust is to do those jobs that can best be done by a permanent prefessional corps of astronauts with that professional corps, and to perform the specialized jobs that require particular kinds of single mission training with those people best adapted to do the work.

SUPER GUPPY TRANSPORT

Mr. BOLAND. On RD 2–9 you indicate that you are planning to procure a "Super Guppy" transport.

Dr. FROSCH. Yes, we have done so.

Mr. BOLAND. It sounds like "Seasame Street."

Dr. FROSCH. It looks like "Sesame Street," too. It is a very fat airplane.

Mr. BOLAND. It is for cross-country transportation of large payloads to and from the Kennedy Space Center. I would like to know, however, whether it was justified in your original Fiscal Year 1979 budget?

Mr. YARDLEY. I don't believe it was a special item. Funds for the transportation requirements are included in the Space Flight Operations budget line item. The Super Guppy procurement has been studied for a year or two, and is clearly cost effective when compared to the other modes of transportation. In addition, there is no other efficient way, for example, to get an assembled and checked-out Spacelab from Kennedy to Vandenberg without it.

Mr. BOLAND. Who built the Super Guppy?

Dr. FROSCH. It is an aircraft that we have been leasing for transporting payloads since the Apollo days.

Mr. YARDLEY. It is a big, fat modified cargo airplane that can carry a 60x15 foot payload.

Dr. FROSCH. I would describe it as a DC–4 but with a very fat fuselage and a large, long area on top.

TELEOPERATOR RETRIEVAL SYSTEM

Mr. BOLAND. On page RD 2–11, the justifications detail the Payload and Operations Support program, under which you earmarked $20,500,000 in FY 1979 for the Skylab reboost/deorbit mission, also known as the Teleoperator Retrieval System. The Committee was skeptical about the possibility of the mission being successfully completed in the time available. In December, NASA discontinued all plans for reboosting Skylab. Would you give us your assessment of Skylab's situation? Are you satisfied with the way the decisions were reached—both the decision to go ahead with it, the justification for that decision, and the decision to cancel it as well as the justification for cancellation?

Dr. FROSCH. I am satisfied with the whole flow of decisions. At the time we decided to go ahead, it looked as though Skylab was sufficiently healthy so that we could control it for the necessary time. We had a reasonable set of predictions of what the sunspot situation was, and the Shuttle schedule looked as if everything would flow together well.

Consistent with the Committee's request, we carefully tracked and reexamined that situation. Then we had some slip in the Shuttle schedule, and the sunspot situation became better and then worse. Most importantly, in my mind, as we continuously watched the condition of systems on the Skylab itself, we began to see signs that I would describe as the characteristics of decay of the systems. From time to time, we would have a battery charger fail or a battery fail or some other element fail. When we looked at the situation, we saw it had all the characteristics of the natural death of the system. When we projected that situation ahead, there was a real question as to whether or not we would be able to control Skylab long enough.

Putting all those factors together, we concluded that it was too low a probability to continue and made the termination decision on that basis.

Mr. BOLAND. There was $20,500,000 provided in the 1979 budget for this program. The Conference Committee Report indicated that only $10,000,000 could be obligated for the Teleoperator Retrieval System without additional Committee approval.

It also stated that the balance of $10,500,000 should be used for the Shuttle, if the Teleoperator was concelled. I notice on RD 2–12 that there is a reference to this matter. I presume that you complied with the Conference Committee Report?

Mr. YARDLEY. Yes, we have.

THRUST AUGMENTATION

Mr. BOLAND. We will turn to RD 2–13. The line item called Thurst Augumentation indicates a need for initial funding of $15 million to carry on studies leading to an implementation decision that can be deferred until Fiscal Year 1981.

What would be the total cost of the thrust augmentation package?

Mr. YARDLEY. Our present estimate, Mr. Chairman, is about $250 to $350 million. I want to add that this is a preliminary estimate and is

not based on in-depth data. We want to get that work done before we put together the FY 1981 budget.

Mr. BOLAND. Before we commit ourselves to this program of thrust augmentation, it is important that we come to some agreement concerning whether that added lift capability is actually needed in calendar year 1984, as the justification suggests. So let us review how you came to the current situation that leads you to believe that you need thrust augmentation for the Shuttle system.

The Shuttle was originally guaranteed to the user community to be able to lift 32,000 pounds and retrieve 25,000 pounds into and from a 98 degree polar orbit for launch from the Vandenburg Air Force Base. That capability is known as "Reference Mission Four." Against that capability, the Shuttle is currently about 10,000 pounds overweight, is that correct?

Mr. YARDLEY. 8,000 pounds.

Mr. BOLAND. 8,000 pounds overweight?

Dr. FROSCH. We keep a 3,000 pound margin for safety against an individual mission.

Mr. YARDLEY. Basically, the overweight is just a part of it. The whole performance results in a net capability 8,000 pounds below the original mission.

Mr. BOLAND. By a series of weight reductions in the Orbiter and in the external tank, you can bring the deficit down to about 4,800 pounds. On top of that, you would like to have a margin of an additional 3,000 pounds. Is that correct?

Mr. YARDLEY. That is the 8,000 pounds.

Mr. BOLAND. All right.

Mr. YARDLEY. The 8,000 consists of the 3,000 pound margin, plus the 5,000. The current weight saving plan will get it up to within 5,000. However, we need margins because some of those weight saver approaches aren't going to turn out to be good enough.

Mr. BOLAND. So what do you need for thrust augumentation; roughly how many pounds?

Dr. FROSCH. We need thrust augumentation equivalent to 8,000 pounds of weight capability.

Mr. BOLAND. If I understand correctly, it is possible to further reduce the deficit on what we might call "Mission X" and still maintain a deploy and retrieval capability by off-loading various systems that are not required for safety. I understand that would gain you approximately 3,000 to 3,500 pounds of additional capability. Is that correct?

Mr. YARDLEY. That is correct.

Mr. BOLAND. All right. Turning to the justification on RD 2–13, it states in the first paragraph, "The current projected capability is not sufficient to perform this mission." By that statement, what you are really indicating is that you don't have the capability to perform Reference Mission Number Four. Is that correct?

Mr. YARDLEY. That is correct.

Mr. BOLAND. In the next sentence you indicate "Payloads requiring the full lift capability have been identified." What payloads have been identified as requiring full lift capability?

Mr. YARDLEY. Any Spacelab from the Western Test Range with a pressurized module will be flying with only 24,000 pounds of Shuttle

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capability. Now these are for NASA payloads. The other payloads are classified.

Mr. BOLAND. A briefing before another committee, indicated that thrust augumentation was not really required even in 1984. It would appear that there was no foreseen requirement in regard to some DOD payloads in the 1984 or 1985, or even 1986 timeframe that require thrust augmentation. If the necessary lift capability can be accommodated with planned weight reductions underway currently, and by off-loading various equipment from the Orbiter, then is it possible that thrust augmentation may be delayed?

Mr. YARDLEY. It is one of the extremes. You can delay it, and people will design around it, and design their payloads to live with the limitation. The problem, from an overall point of view, is that it is going to cost the country money to split complementary payloads up into single or smaller payload packages. I would like to comment on the basic Vandenberg problem.

When we put a 65,000 pound payload into orbit from Kennedy, we really put 300,000 pounds into orbit because we have all of the weight overhead in the Orbiter, such as the thermal protection and the engines. But when we go to Vandenberg, we lose about 10 percent of the performance because of the rotation of the earth. That 10 percent is 30,000 pounds, which is almost half of the payload. At Vandenberg, we will have half the capability of Kennedy to start with. We need the 30,000 pound capability from Vandenberg to be viable and economical for the Shuttle launch. You really need that capability.

Dr. FROSCH. Let me comment on that subject. It appears that the DOD would like to design some things to be more efficient and to use the entire promised capability of the system. At a slightly later point, they would like to have the full all-up launch capability.

The other comment I need to make is this: The question of whether we maintain the option in the system to go to thrust augmentation is extremely important with regard to FY 1980 budget requirements. As a part of the design process, we need to be sure that all of the facilities are built so that if we decide to go to thrust augmentation, we won't have to make major modifications to the facilities.

Mr. BOLAND. You can do the study work with the requested $15 million in the 1980 budget, is that correct?

Dr. FROSCH. We need the $15 million to do the study work on a timely basis. The decision on whether we require the $250 to $350 million that John referred to, in order to achieve the thrust augmentation is a decision that will be made during the FY 1981 budget process.

Mr. BOLAND. We are concerned whether you really need thrust augmentation in 1984, not just that thrust augmentation is ultimately needed. It probably will be, because of the slippage in the Spacelab and the Shuttle schedule——

Dr. FROSCH. The key factor for the FY 1980 budget is that we need those funds to do the analysis to assure that we know what we are doing. It is not at that point a full commitment to going ahead with the development or even when to go ahead. But we ought to understand it and we need to do the analysis and work so that we can understand what it is likely to cost. The current estimate is just a preliminary

kind of estimate, and we need to do more analytical work to know what a more precise estimate would be.

In general, the case of thrust augumentation is a little bit like the case of the fifth orbiter. It is a question of whether one wants to provide additional funds after a substantial investment to bring a system into being in order to get the most out of it. With the kind of thrust enhancement we are talking about now, we could bring the payload-carrying capability of the system up to the maximum that the structures can withstand. It is one way of saying that we can get the optimum possible capability from this system. I think in the long run we will want to do that. The question of whether we will want to do it in the short run will depend on the results of this analytical work and on how the mission structure really begins to evolve. The first time there would be a crucial decision for that would be the FY 1981 budget.

Mr. YARDLEY. One of the pressures that we feel in terms of having it as early as feasible is that our military and intelligence groups have very important work to do. They are making decisions on the basis of what has been demonstrated. So I could visualize that even if we went ahead in 1984 or 1985, they might not count on it until 1989 or 1990, and therefore some payloads would be nonoperable. We have seen that happen in even this year's budget.

Mr. BOLAND. What caused the substantial increase in weight of the Orbiter from the time of our discussion at the joint hearing about a year ago through December when this problem first surfaced publicly?

Dr. FROSCH. John, do you want to comment on that?

Mr. YARDLEY. I am not sure I can give you a detailed answer. The requirement for the helium for the engine seal problem was a couple of thousand pounds, and other weight increases resulted mostly from technical problems.

Mr. BOLAND. On page RD 2–23, the justification outlines the Space Transportation System Operations. The 1980 budget estimate for Shuttle operations increases substantially, from $21,200,000 to $114,600,000, and the payload support operations increase from $12,200,000 to $38,-500,000. This, of course, reflects the Shuttle becoming an operational vehicle. How are these estimates tied to the launch schedule? There has to be some relationship between the two. Obviously, if the first manned orbital launch is delayed 6 months and the operational flights, which begin with flight number seven, are also delayed another 6 months, that would have some effect on funding requirements.

Mr. YARDLEY. Further slippage in the Shuttle schedule would result in some slippage in the operations funding requirements, and some of the STS operations funding could be diverted because we would not need to build the tanks or some of the other items as soon. This money is required for long-lead items for the first operational flight planned in February 1981, and for the early work for the flights after February 1981. If there were another major slip, it would be feasible in 1980 to slow some of the operations work down, if we have orbital flights left at that time.

Mr. BOLAND. Will you supply for the record the actual dollar amounts and how they are tied to the schedule?

[The information follows:]

Response. The FY 1980 funding plan for STS Operations is based on a February 1981 initial operating capability at the Kennedy Space Center. This first operational flight date is consistent with a first manned orbital flight in November 1979 and with the completion of the orbital development flight test program with an interim period to permit Shuttle physical adjustments and outfitting for the operational era. A delay in the first manned orbital flight would not necessarily result in an equivalent delay in the initial operational capability.

Based on the February 1981 initial operation capability (IOC), the early operations planning includes a total of seven flights in FY 1981, and sixteen flights in FY 1982. The FY 1980 budget estimates for STS operations, which have been adjusted for anticipated reimbursements from Shuttle users, provide funding for the procurement of long lead hardware items and flight operations planning and support required for these early Shuttle operational missions. More than 80 percent of the FY 1980 estimates for Shuttle operations is for the procurement of external tank and solid rocket booster hardware required for the early operational flight schedule. Most of the FY 1980 funding requested for Payload Support Operations is for the procurement of inertial upper stages and spinning solid upper stages required for payloads planned on early Shuttle operations flights.

While it might be possible to reduce FY 1980 STS Operations funding requirements on the basis of a delay in early operational missions, the extent of the reduction would depend on an assessment of the cost effectiveness of altering the contractual activities for hardware fabrication and delivery due to flight schedule variations.

Mr. LILLY. Mr. Chairman, I would like to add that if there is a schedule slip of a month or two months, it will not generally have a direct impact on the FY 1980 STS Operations funding requirements. Most of these funds are required for expendable items, such as external tanks and things of this nature that we put on contract. You can't adjust those contracts up or down, based on some particular schedule slipping, without adding to the cost.

PRIVATE SECTOR SHUTTLE NEEDS

Mr. BOLAND. Let us turn to RD 3–1, the Expendable Launch Vehicles Program. You are requesting $70,700,000 for that program in FY 1980, and that compares with $71,500,000 in 1979. Can you explain how this estimate is actually put together and exactly what it is buying? As part of that explanation, will you expand in some detail, on the arrangement NASA has with the user community concerning the Shuttle operational missions? I understand that, in terms of the financial impact on NASA, the key date is the first manned orbital launch. The longer that the first launch slips, the more money it costs NASA to guarantee the user community a launch with a conventional expendable rocket. Tell us how that works and how much of a reserve is here for that purpose.

Mr. YARDLEY. With respect to the first point, we have planned the Expendable Launch Vehicle Program for NASA in terms of flights, schedules, and so on. We determine the total requirements and then subtract the anticipated reimbursables to arrive at our NASA budget estimate.

The second thrust of your question focuses on the transition plan. This plan centers around our most popular vehicle, the Delta. NASA plans to phase out the Delta launch vehicle operations at the Eastern Test Range by the end of December 1980, except for Delta backup launches, if needed. Any Delta-class spacecraft which is required to be launched prior to June 1, 1980, will be scheduled for launch on Delta. During the transition period, defined as June 1, 1980 through June 30,

1981, Delta-class spacecraft are to be designed for launch on either Delta or Shuttle and will be scheduled for launch on Shuttle.

NASA will preserve a Delta backup capability at no cost to Shuttle users until the actual First Manned Orbital Flight or nine months prior to the users Delta backup launch date, whichever occurs first. Until that time, NASA will preserve backup launches for those users requesting Shuttle launches prior to June 30, 1981.

Users will reimburse NASA for the launch mode actually utilized for their payloads plus full costs of any Delta backup maintained for the user after the decision date and any additional expenses incurred on the users' behalf. If the user elects a Delta backup launch, all payments made by the user toward the Shuttle launch will be credited toward the Delta backup launch, and there will be no cancellation fee charged to the user. The estimated cost of a Delta launch is approximately $22 million, whereas the Shuttle cost is around $7 or $8 million for a Delta-size payload. What we are doing is keeping the Delta hardware production line open at the lowest possible rate we can until FMOF (first manned orbital flight); that is, building one Delta every three months.

Each Delta is going to cost us, just to carry the hardware parts, something like $8 million. We estimate that by this fall we will have something like $20 or $22 million of Delta hardware in the pipeline. If it is not used as backup, then NASA will have this hardware available for Vandenburg launches planned for Fiscal Year 1983 and 1984. As a matter of fact, we already have some scheduled. Some of these vehicles, which could be used as backup, will actually be scheduled for flights out of Vandenberg until the Shuttle is operational there.

We don't know what the net cost is going to be. I am pretty sure we will be needing some of these vehicles. With any settlement for those we use either as backup or as flights out of Vandenberg, I don't think the net is going to be more than $10 million to provide this capability.

We have no more Delta launches for commercial users after this year, and start scheduling only on the Shuttle, so it will help our traffic situation and help us use the Shuttle efficiently.

In the Atlas Centaur program, it is somewhat different. We don't have any other uses for Atlas Centaur as we do for Delta at Vandenberg, and we have not offered a transition plan for that vehicle. We got into quite serious negotiations with the Intelsat people for Intelsat-V series of launches. The Intelsat people have bought four Atlas Centaur flights and they are trying to make up their mind whether to go on the Shuttle or on the Ariane for flights five, six, and seven. We decided that we would provide them one backup after February 1981, if they would guarantee two Shuttle flights, or one additional Atlas Centaur and one Shuttle flight.

The final compromise was that they took our two Shuttle flights with one Atlas Centaur backup through the first manned orbital flight. On that vehicle, Intelsat will reimburse NASA for the full price, if they choose to use it.

Mr. BOLAND. What is the price for the Ariane?

Mr. YARDLEY. The Ariane people publicly stated that their price is whatever it costs to fly the payload on the Shuttle.

Dr. FROSCH. Their price is pegged to the Shuttle. They have announced they will slightly undercut the Shuttle price.

Mr. YARDLEY. Basically, to take an Atlas Centaur payload the Ariane will charge on the order of $23 million, which is about what the Shuttle is.

Mr. BOLAND. I have a note that says that the price for Ariane is about $25.29 million while the indicated price for the Shuttle launch is estimated at about $28 million.

Mr. YARDLEY. That is in real year dollars.

Mr. BOLAND. Could you indicate what Intelsat is paying for the Atlas Centaur launches?

Mr. YARDLEY. The approximate cost of the first four was about $39 million each.

The estimated cost for the backup, if they actually continued after FMOF, is around $50 million.

SPACE SCIENCE PROGRAM

Mr. BOLAND. We will turn to SS–1 and the Space Science Program, where NASA is requesting $601,600,000. This compares with the Fiscal Year 1979 current estimate of $505,400,000. The increase is about $100,000,000 above the 1979 level. It doesn't include any new starts. That is correct, isn't it?

Dr. HINNERS. That is correct.

PROPOSED FY 1980 SPACE SCIENCE STARTS

Mr. BOLAND. Two new starts were proposed for Space Science in 1980, the Gamma Ray Observatory and the Venus Orbiting Imaging Radar mission, but neither was funded.

What are the candidates for new starts in Fiscal Year 1981, and how would you rank them according to priority?

Dr. FROSCH. We are now considering three possible new starts for FY 1981—the two that you mentioned, the Gamma Ray Observatory and the Venus Orbiting Imaging Radar mission, and the third is a cometary mission, probably a fly-by of Halley's Comet and a rendezvous with Temple 2.

The question of priority involves a number of difficulties. One is an estimate of what is scientifically most promising and interesting, which is different for different parts of the scientific community. Second, two of those have some relationship to orbital mechanics. The Venus Orbiting Imaging Radar and the cometary missions have opportune times to do them and inopportune times to do them in terms of launch constraints.

VOIR, if not started in FY 1981, would be difficult to do until 1991. Halley's Comet only comes around every 76 years. Therefore, if we don't get started and be prepared to fly in 1985, we won't be ready for this pass of Halley's and would have to wait 76 years. It happens to be a particularly interesting comet because it comes around infrequently. It is, therefore, thought to be less altered by sunlight and solar wind than the other comets.

Temple 2 comes around every three years. So I guess that it is not quite so time urgent. We would certainly, I think, try to start one of those two planetary missions—VOIR or a cometary mission—and the Gamma Ray Observatory in FY 1981.

There is one other question with the cometary mission, and that is our assessment, when we go into the FY 1981 budget cycle, of whether we are or are not technologically ready to start it.

In order to do the cometary mission, we would have to depend on the solar electric propulsion system. We think we are in the right phasing to be able to prepare for that cometary mission with that propulsion system, which is certainly required for the mission. I can't give an absolute answer yet, but those are the factors involved in the choice.

FULL FUNDING FOR NASA SATELLITES

Mr. BOLAND. What about converting to a full funding system for NASA satellites? Doesn't that really give you a more accurate picture of what the total cost impact of these programs is? We do it in the DOD programs; we do it in hospital construction for Veterans Administration; and the President suggests that we do it. In fact, he not only suggests but directs the Congress to do it with reference to the building of dams and reservoirs. What about full funding for satellites? Would the cost shock the public too much?

Dr. FROSCH. No, I think full funding for our R&D programs would have the problem that each one of these spacecraft is a development program. R&D is not as firm as deciding to build a hospital or a dam with a given design and engineering system which has been very well defined for a long time. Each development is a new challenge.

That characteristic makes it, to my mind, extremely difficult to do on a full-funding basis. I might also add that my experience in the Navy Department with the full funding of ship building, which is where it is used most, did not leave me with great comfort that the full-funding technique is particularly helpful in being sure about what costs are going to be.

Mr. BOLAND. Sitting on this Committee over the years leaves me uncomfortable with the notion that any price that might be targeted for a satellite at any one point in time will really reflect the total price. I can point to any number of examples. I guess there is great difficulty here, isn't there?

Dr. FROSCH. I think what would happen would be that while we would be fully funded initially, as the development went on there would be changes. We would, in fact, be coming before the Committee for changes, and that might be difficult for both parties.

In terms of NASA's record we have done fairly well on estimating the development costs. There have, however, been problems in predicting what the operational costs would be.

DISCOVERY OF JUPITER'S RING

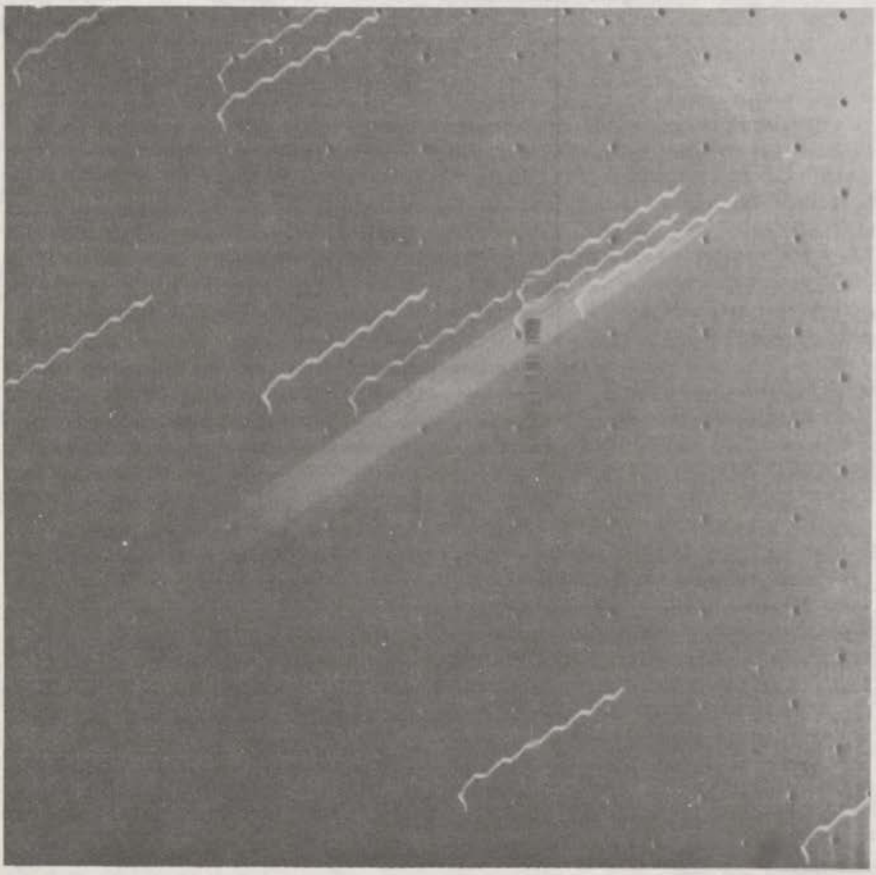
Mr. FROSCH. Mr. Chairman, with your permission, I would like to mention one of the exciting discoveries about Jupiter, based on the Voyager observations. We just recently received word of this. One of the discoveries in the past couple of days is that there is a ring around Jupiter.

There was a portion of the Voyager imaging sequence which was intended to look for a Jupiter ring—like a Saturn ring—as it passed through the equatorial plane. Here is a photograph that doesn't look like much, but is unambiguous confirmation that there is a rather

tenuous ring close to Jupiter, farther in than the innermost of its moons.

We have known for a long time that Saturn has rings. In the past year, we learned that Uranus has rings, as determined by the vanishing of a star prematurely when Uranus went in front of it. Now we know, thanks to Voyager, that Jupiter has a ring. Therefore, the mystery of the outer planets is no longer a question of why Saturn has rings and the others do not; the question has suddenly become this: If Uranus, Saturn, and Jupiter have rings, what about Neptune and Pluto? We have almost no information on those planets.

This picture, which was taken with a long exposure, shows these tracks of stars. It was a 12 minute exposure, and those are the images of stars smeared by the motion of the spacecraft. As you can see, this is the streak that verifies by its position and angle, that there is in fact a ring around Jupiter.



One consequence is that we will want to look at the program schedule of activities for the Voyager 2 encounter with Jupiter to be sure that, within the bounds of what can be done with it near the planet, we will have a good look at that ring.

I thought this picture would be interesting. It will be publically released at 2:00 p.m.

Mr. BOLAND. When is the Voyager 2's closest encounter with Jupiter?

Dr. FROSCH. July 9th is the closest time.

Mr. BOLAND. What will the second Voyager do that the first has not done?

Dr. HINNERS. Our initial plan was to send the two Voyager spacecrafts as a complementary pair. For the satellite encounters, we had targeted Voyager 1 to concentrate primarily on Io and secondarily on Ganymede and Callisto. Voyager 2's prime target in Jupiter's satellite system is Europa, which did not receive intensive coverage in the first mission, as well as better coverage of Ganymede and Callisto.

In terms of the planet itself, Voyager 1's high resolution photography has been concentrating on the Great Red Spot. Therefore, Voyager 2 will study some of the other atmospheric phenomena, such as these wispy, white structures you can see. We will also be getting a different look at the atmospheric circulation patterns.

Voyager 2 will go through a different portion of the magnetic structure in the intense radiation belt, helping us to get an idea of the extent of the belt and how it fits into our theory, which is now a very crude model. We won't have a very precise measurement until we get an orbiter to Jupiter, which is one of the objectives of the Galileo mission.

Both Voyager spacecrafts will be heading on for the Saturn encounter. There will also be many different objectives. Voyager 1 has the prime science objectives of looking at Saturn, its ring structure, and its big satellite—Titan. If those objectives are all successfully met, we will then reprogram the Voyager 2 spacecraft to do some occultation observations for Titan then target it on to the Uranus encounter.

Mr. BOLAND. What is the significance of the ring around Jupiter?

Dr. HINNERS. One of the problems we are trying to understand is how planets form in the first place. There is good evidence from meteorite studies that they don't form initially as large individual bodies, but are collections of debris. We have a difficult time understanding the characteristics of initial debris that might accumulate into a planet, and what some of the dynamics of that process are.

Prior to this type of mission, which discovered these new rings, Saturn appeared to be the only place where we could get a look at the fragments of material that might accumulate into a planet-size body. With the discovery of these rings and through analysis of the particle size and distribution, provided from the following missions, we will get data on the planet's composition. We think we can start to probe the basic problem of how material accumulates as the planet is formed; both initially around the planet, and later as it aggregates to form the planets and the satellites.

SPACE TELESCOPE FUNDING

Mr. BOLAND. We will turn to RD 4–9, the Space Telescope. Is this the peak funding year for the telescope with your request of $112,700,000?

Dr. HINNERS. This is the first of the peak development years. There are two peak years, FY 1980 and 1981, which are about the same level in FY 1980 budget dollars.

Mr. BOLAND. The total cost of this program last year was estimated at $460,000,000 to $500,000,000, expressed in 1979 dollars. Is this program on schedule, and is it within cost?

Dr. HINNERS. Yes, it is.

Mr. BOLAND. On RD 4–11, the statement from the justification discusses the contract for grinding and polishing the 2.4 meter mirror. I thought that one of the reasons why the 2.4 meter diameter was picked was because the mirror blanks were already available. Are the blanks that are being polished under contract, the same ones that are discussed here?

Dr. HINNERS. These mirror blanks are being produced by Corning for the Space Telescope project.

Mr. BOLAND. The justification discusses the contract for grinding and polishing of the 2.4 meter mirror. I though one of the reasons why you picked the 2.4 meter diameter was because the mirror blanks were already available. Were they available?

Dr. HINNERS. Not for this project, Mr. Chairman. We picked the 2.4 meter diameter because we thought we would be extending the technology base too far to go to the 3.0 meter. That is why we looked at three options—3.0, 2.4 and 1.8 meters.

Mr. BOLAND. Who is the contractor?

Dr. HINNERS. Perkin-Elmer is the contractor for the optical telescope assembly. The mirror blanks are being procured from Corning.

SOLAR POLAR MISSION

Mr. BOLAND. Also on page RD 4–11, we have the solar polar mission. This request represents the second year for the development cost of this mission. The total estimated cost is approximately $250,000,000, excluding the launch costs on the Shuttle. Is this program on schedule and within cost?

Dr. HINNERS. Yes, it is on schedule, and the cost estimate still looks good.

Mr. BOLAND. As I understand, from what you suggested in the hearings last year—page 78—was that by a delay of one year, the mission would lose about five degrees of solar latitude capability. Is that correct?

Dr. HINNERS. Yes, sir.

Mr. BOLAND. I also understand from last year's hearings that the scientific community would agree that it would still be worth doing the mission if you lost only five degrees at one launch opportunity, but that to lose two launch opportunities and have it slip two years would not make it worth doing. Is that correct?

Dr. HINNERS. That is correct.

UPPER ATMOSPHERE RESEARCH PROGRAM

Mr. BOLAND. Please turn to RD 4–20. Under Research and Analysis, I note that the Upper Atmosphere Research Program has no funding for 1980 as compared to a level of about $11.9 million for the past two fiscal years. What happened to that program?

Dr. FROSCH. There has been an internal transfer of responsibility for the Upper Atmosphere Research Program from Space Science to Space Applications because we had atmospheric research in both areas.

PLANETARY EXPLORATION PROGRAM

Mr. BOLAND. And what about the search for extra-terrestrial intelligence; has that been eliminated in 1980?

Dr. FROSCH. That is not in this budget.

Mr. BOLAND. We will turn to RD 5–1 which displays a table showing the total planetary exploration program. You are requesting $220,200,000 in 1980 which compares with $182,400,000 in 1979. The Jupiter orbiter probe, now known as Galileo, captures the largest percentage of your budget. Again, there are no new starts in this program in 1980.

Let me ask you a question or two about Galileo. During the past few months the staff has been briefed by Dr. Hinners on the problems concerning the weight of this spacecraft. Briefly, the problem is that the weight approaches the maximum that can be carried on the inertial upper stage, which fits into the Shuttle bay. That weight limitation is roughly 4,500 to 5,000 pounds.

The current planning indicates that you will fly the Jupiter Orbiter Probe on Orbiter 099, which is the second orbiter that will become available for flight. In fact, this will be the first mission of Orbiter 099 and the purpose of using that vehicle rather than Orbiter 102 is that 099 is somewhat lighter. Is that correct?

Dr. HINNERS. Yes, sir.

Mr. YARDLEY. Let me just say something. We would like to use Orbiter 099. However we are keeping open the option of using Orbiter 102 if 099 is not available and if 102 is able to provide the required performance. I don't think that Orbiter 102 will increase beyond its current weight. We are going to deliver that vehicle to KSC this month. So, I don't think the weight can go up too much.

Mr. BOLAND. This mission, as we were told in the last couple of years, has a very narrow launch window and it is scheduled to be launched in January 1982. Is that correct?

Dr. HINNERS. Yes, sir.

Mr. BOLAND. Under the current schedule, Orbiter 099 is not due to be delivered to the Cape until September, 1981. Given the potential for additional slippage, is that sufficient time to get this mission off in January, 1982?

Mr. YARDLEY. We don't feel it is too close to plan on. We would rather use Orbiter 099 and have a better weight margin.

But, as I said before, we are making sure we can do the mission with Orbiter 102. Depending on the circumstances, we may have to reconfigure Orbiter 102 and take some cryotanks, or something else out, which we prefer not to remove because of the cost involved. There are many small items that we identified as candidates for weight reduction.

MARS VIKING MISSION

Mr. BOLAND. Dr. Hinners, let me ask you about the Mars Viking mission, which placed two landers on the surface of Mars in 1976.

I notice in a recent issue of "Aviation Week and Space Technology" that exhaustive analysis of data returned by the twin Viking landers supports initial conclusions that there is no sign of life on that planet.

I also notice that many of the scientists involved in this conclusion indicate that it would be necessary to fly a follow-on mission before a final conclusion could be made whether Mars supports life.

How high a priority, in your own mind, is a follow-on mission?

Dr. HINNERS. In my mind, a Mars follow-on mission of this kind is a priority which puts it out of the post-1984–1985 time period relative to the other planetary missions we are considering, which include the Venus mission, a comet mission, and a Saturn orbiter and probe type mission.

Dr. FROSCH. I think we all have reached that conclusion somewhat reinforced by the fact that the discussions in the scientific community as to the nature of that mission have not converged very rapidly on a point of agreement as to exactly what to do.

I think they are approaching an agreement that a sample return is what is required, but exactly what strategy of sample return is still very much in the discussion stage.

Mr. BOLAND. What might be the cost of a follow-on mission?

Dr. HINNERS. We have looked at several types. There is agreement that the life detection thrust of the Viking should not be the main thrust of any Mars follow-on mission at this time. The thrust should be one oriented to understanding the planet, its atmosphere and evolution, and the basic chemistry which in part might help explain why the organics haven't arisen there.

An orbiter type mission has been looked at as part of the long term strategy; a geochemical, geophysical orbiter of Mars, which could be linked with an eventual sample return mission.

The geologists and chemists are pretty well convinced that to get part of the sample back here for analysis in terrestrial laboratories is probably going to be the best way to make a significant jump in our understanding of the planet.

Mr. BOLAND. What about cost? Has any cost been projected for a follow-on mission?

Dr. HINNERS. Just crudely, since we do not yet understand it very well. A single orbital-type mission to Mars would fall somewhere around the $250 million range.

For a Mars sample return mission—again, it is very preliminary—a rough estimate would be probably $1.5 billion.

Mr. FROSCH. Bringing something back is very expensive.

Mr. BOLAND. If you had excess money, and you had to make a choice between flying a Saturn Orbiter and Probe or a second mission to Mars, what would be your choice?

Dr. HINNERS. Saturn Orbiter and Probe.

Mr. BOLAND. Would that be yours also, Dr. Frosch?

Dr. FROSCH. I think I would agree.

Mr. BOLAND. That would be the choice of everyone in the room, I take it?

Dr. FROSCH. I don't know that we have asked everybody in the room. A Saturn Orbiter and Probe mission would be absolutely new infor-

mation; in the Mars case, we would be building on the basis of a considerable amount of information.

Mr. BOLAND. I want to yield at this point to the new Member from Minnesota, Marty Sabo. Any questions, Marty?

Mr. SABO. I am glad to be here. I am sorry I missed the rest of your presentation to this Subcommittee. I listened to testimony on urban mass transit. Somehow that was a little closer to home. But, I look forward to hearing your presentation and your response to questions this afternoon.

Dr. FROSCH. Thank you.

SPACE APPLICATIONS PROGRAM

Mr. BOLAND. We will turn to the Space Applications program and its outline on page RD 7–1 of the justifications. You are requesting $332,300,000 in 1980 as compared to $274,800,000 in 1979. Dr. Calio, on page 90 of last year's hearings, you indicated that the Applications budget was dependent somewhat on your view that a good deal of policy and homework had to be completed in regard to how the United States was going to go about moving applications successes into operational systems.

You said you hoped to get that work done during the past year, and then you would know a little bit better about where to go in the applications area.

So, we have now reached that year and we would like to know where we are going.

Dr. CALIO. There has been progress this year. As a result of several studies, Presidential Directive 42 was issued, spelling out the areas of emphasis for Space Applications. The President has also requested two additional studies that are being conducted now.

One is a study of a national integrated remote sensing activity, which should be finished by late summer. Another is the potential of private sector commercial participation in the implementation of remote sensing activities throughout the United States. That study, which is chaired jointly by NASA and the Department of Commerce, will also be completed late this summer.

PROPOSED NASA/NOAA/NAVY VENTURE

Mr. BOLAND. There are no new flight starts approved by the Office of Management and Budget for the Applications Program in 1980. One new proposed start was the National Oceanic Satellite System. It was to be a joint project with NOAA and the Navy. Was that your number one new start priority?

Dr. CALIO. Yes, sir.

Mr. BOLAND. Will you be proposing that for Fiscal Year 1981?

Dr. CALIO. Yes, sir.

Mr. BOLAND. How would that program be different from Seasat? Are the objectives the same?

Dr. CALIO. They are somewhat different. The National Oceanic Satellite System (NOSS) would be a step to demonstrate the transition from an experimental system to an operational one.

We are studying a limited operational demonstration. We have always had difficulty in bridging the gap between experimental and operational systems. Part of that difficulty rests with the operation of the ground segment.

Therefore, in our NOSS planning, we are focusing on the ground segment, the data handling activity, and the ability to keep satellites in orbit to provide continuous data for a demonstration period of five years. Our planning assumes one satellite in orbit for the collection of the data, and a second satellite in orbit as a backup. Assuming a three-year lifetime for the first satellite, we would then retrieve it, refurbish it, and relaunch it while the second satellite was being used. This approach would provide continuity of service for a period of five years.

Mr. BOLAND. What is the total cost of that program?

Dr. CALIO. The total cost was estimated, in the agency's Fiscal Year 1980 budget recommendation to OMB at about $600 to $700 million. Two-thirds of that cost would be in the space segment, to be borne by NASA; and one-third for the ground segment and operations, to be borne by the Navy and NOAA. We are now looking at a redistribution of funding responsibility along the lines of our current arrangements with NOAA. As you recall, with the NOAA satellites, we fund the first one, the R&D operational prototype, and they pay for all of the subsequent ones. We are reviewing this approach to see if it is a viable concept for the National Oceanic Satellite System.

Dr. FROSCH. Mr. Chairman, while there is no new flight start in the budget, there is what is called the agricultural research initiative in the Applications program. It is a major follow-on program to the Large Area Crop Inventory Experiment (LACIE) and will be a cooperative venture among NASA, the Department of Agriculture, and NOAA in the Department of Commerce. This agricultural research initiative was slightly higher on our zero-based budget priority list than the National Oceanic Satellite System. It is not a flight start, but it is a utilization of Landsat and weather satellite data, as well as agricultural modeling. It is discussed in our justification a little bit later on page RD 7–17.

Dr. CALIO. The agricultural research program is somewhat different from the experiment that was performed in LACIE in that the Department of Agriculture is the lead agency for this activity, and they are proposing to fund about half of the program. Approximately half of the total funding would be NASA and the other half would be the responsibility of the Department of Agriculture and NOAA.

STEREOSTAT FISCAL YEAR 1979 FUNDING

Mr. BOLAND. What about the Stereostat program? There was $500,000 added to the Fiscal Year 1979 budget for this program. Where is that carried in your budget?

Dr. CALIO. It is carried within the non-renewable resources line on page RD 7–16. There is $500,000 in Fiscal Year 1979 planned for Stereosat definition studies.

Mr. BOLAND. Within the $2.7 million for non-renewable resources in fiscal 1979?

Dr. CALIO. Yes, sir.

Mr. BOLAND. On the next couple of pages you are explaining the Applied Research and Data Analysis Programs, but I don't see anything about Stereosat. What happened to it?

Dr. CALIO. Stereosat is included under the discussion of advanced studies on page RD 7–19.

Mr. BOLAND. That doesn't give us much information though, does it?

Dr. CALIO. No, it doesn't. In Fiscal Year 1980, we are planning to continue the definition studies for Stereosat at about a $600,000 level.

Mr. BOLAND. What sort of program is it? As I understand it, this program received a great deal of attention from the oil and gas industry, via the Geosat Committee, which was organized to support this particular mission. Isn't that correct?

Dr. CALIO. That is correct, Mr. Chairman.

Dr. FROSCH. We believe that Stereosat is not a research and development problem. It would be an operational use of a technology we understand. Therefore, we think that it would be reasonable for the industry to be a financial participant, and not have it simply a government program with the results furnished to the industry. We have been discussing with the Geosat Committee a number of options for industrial financing. One of the options is for the government to invest in the satellite and acquire the data, but sell the data to the industry as a way of recouping the investment.

The industry has conducted a survey which indicates that there probably is a market for the data, more than enough to reimburse the development and flight costs. We are still in the process of trying to see whether, if the system is established, the industry would be willing to make the commitment that the data will be purchased.

Mr. BOLAND. How much is carried in the Fiscal Year 1980 budget request for this study effort?

Dr. CALIO. $600,000

Mr. BOLAND. What is the total cost of the program?

Dr. CALIO. For Stereosat?

Mr. BOLAND. Yes.

Dr. CALIO. We only have planning estimates right now. It would be somewhere around $100 million for the program.

Mr. BOLAND. Does this enjoy any particular priority?

Dr. FROSCH. Not at this time, because we felt it ought to be an industry participation program. If it becomes one, then we would give it considerable priority because the data would be valuable.

In effect, we are negotiating who really should carry the ultimate load, whether it should be carried by the taxpayers or by this particular industry.

Mr. BOLAND. The decision to fund Stereosat was really the Committee's decision.

Dr. FROSCH. Yes, sir.

Mr. BOLAND. It was done because the Committee felt that it was an area that ought to be looked at. We listened to the arguments of a specific special interest group and thought that they had some merit. We were just wondering whether that conclusion by the Committee carries any weight with NASA?

Dr. FROSCH. We will certainly continue the analysis and try to reach a suitable agreement with the industry.

Mr. BOLAND. Do you think it is worthwhile pursuing?

Dr. FROSCH. I think Stereosat is worthwhile pursuing, but we believe the industry ought to be willing to defray part of the costs in some manner or other. We are continuing the technical definition of what this satellite system would be.

Mr. BOLAND. What do you think the industry's share of the costs should be?

Dr. FROSCH. I think that one way to do it is for the capital investment to come from appropriated funds, and for those to be recouped by the sale of data. To make that a reasonable arrangement, before initiating such a flight project I think we must have assurance from the industry consortium, or the individual companies, that they will buy the data at an agreed-upon price.

There appears to be some feeling in the industry that if they press and don't agree too soon to buy the data at a price, then it is possible that the project will be funded and the data will be given to them. We are in that kind of negotiation situation.

OCEAN DYNAMICS SATELLITE (SEASAT)

Mr. BOLAND. We will turn to RD 7-25, the Ocean Dynamics Satellite, SEASAT. This satellite was launched on June 26, 1978, and after 106 days in orbit it went dead after a massive power failure. Who comprised the investigation board that looked into this matter?

Dr. FROSCH. It was chaired by Bruce Lundin, who is the retired director of the Lewis Research Center.

Mr. BOLAND. The investigative board, in looking at the failure, blamed the problem on inadequate design analysis of the spacecraft before and after it was built by the prime contractor, Lockheed Missiles, and on the NASA manager of the program, the Jet Propulsion Laboratory.

Apparently Lockheed totally dropped the ball on this one. It was further complicated by the fact that the flight controller directing SEASAT was new to his job and was not sufficiently knowledgeable of the system he was controlling. What happened?

Dr. FROSCH. I think I could interpret the report as meaning something just slightly different from that, partly from conversations with Bruce Lundin.

I think the statement that the flight controller did not have adequate knowledge of the system and training is a correct statement. But it was not the cause of the failure in the sense that the actual system did not perform the way we would like it to. It is very doubtful that any action by the controller would have saved the satellite.

Mr. BOLAND. So it did not matter who was controlling it?

Dr. FROSCH. No matter who was controlling it, or what the procedures were. It appears to have been a design failure. Since the basic spacecraft was the Agena, the assumption was that all of those spacecraft systems had performed successfully and were being used and carried over intact.

In fact, that was not a completely correct view of what was happening in the engineering. Certain pieces, in particular the slipring assembly, had been redesigned in order to fit the particular circumstances of SEASAT.

The redesign was poor. The elements were put together in a way which, I think, invited trouble. It is easy to see that in hindsight, but it may not have been so easy to see at the time.

I think a fair criticism is that there was not enough managerial monitoring of the Agena spacecraft because it was assumed to be identical with the previous ones. There was not enough attention paid to the fact that some changes were being made and should have been supervised more carefully.

That seems to have been a problem in the manufacturer's organization. I suppose it is fair to say that it is a problem with the NASA supervision of the manufacturer in that the project management also made the assumption that since it was an Agena spacecraft, it did not require so much attention.

The lesson learned or reemphasized is that one cannot make the assumption that a previously used technology, when carried over into a new use, can be allowed to have only minimal managerial attention. There has to be someone responsible for assuring that the hardware and its use are identical or that the changes in design receive the same management attention as the newly developed parts of the system do.

Fortunately, even though it failed prematurely, we estimate that SEASAT acquired enough data to achieve 75 to 80 percent of its preplanned objectives. Most of the essential data was acquired in the early part of the mission.

Mr. BOLAND. Who would have been responsible for waiving a test without proper approval? Wasn't a test waived without proper approval? I am reading from the "Defense Space Daily" which apparently based its information on the data found in the Board's report.

Dr. FROSCH. The requirement for approval would depend on what level of test was involved.

Mr. BOLAND. Important component problems were not reported to project management. A test was waived without proper approval and compliance with specifications was weak.

Dr. FROSCH. A waiver could be granted at any one of several levels. Initially, approval would be within the manufacturer's functions; for certain levels of test, the NASA project management team should have review and approval responsibility, unless it is a subsystem. As I said, it depends on the level of test involved.

Mr. BOLAND. I presume the only reason why there would be no effort to retrieve this satellite is because it is too high?

Dr. FROSCH. It was not designed for retrieval.

Mr. BOLAND. How high is it? What is its altitude?

Dr. FROSCH. It is orbiting at an altitude of 800 kilometers—500 miles. It was not designed with a thrust package that would bring it down to the Shuttle's orbit for retrieval.

Dr. CALIO. It is frozen as far as controlling it is concerned.

Mr. BOLAND. In any event, although it failed before its designated lifetime, NASA believes that the data returned by its operation has verified the feasibility of ocean monitoring from space; is that correct?

Dr. FROSCH. Yes; that is correct.

Mr. BOLAND. You didn't need SEASAT to prove that, did you?

Dr. FROSCH. We needed to demonstrate that those instruments could acquire data that people can use. We think that SEASAT demonstrated these capabilities.

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I would only add that when we have a failure, we regard it as having learned something, and we diffuse that information throughout the entire NASA organization and industry.

Mr. BOLAND. Do you have any recourse against the contractor?

Dr. FROSCH. Essentially the only recourse we have is through the award fee, because it is, as others are, a cost-plus-award-fee contract. This means, as I understand it, that it is legally regarded as a "best efforts" contract.

Mr. BOLAND. The only other area where you could bring any pressure to bear, I suppose, is not to award them any additional contracts in the future.

Dr. FROSCH. We remember our experiences.

APPLICATIONS DATA SERVICE DEFINITION

Mr. BOLAND. On RD 7–40, you describe a small new program, the Applications Data Service definition. You are requesting $2,400,000. Why are these funds needed?

Dr. FROSCH. Do you want to respond to that question, Dr. Calio?

Dr. CALIO. We are trying to define a technique for a data network that will allow any user, anywhere, to obtain timely access to data collected from applications satellites.

The concept is to define what kind of structure is necessary for this to happen with remote sensing satellites, such as Landsat, Tiros, and Nimbus. The people who need this information would be able to go to a catalog; know what is available; and have the data in a standardized format in such a way that they would be able to combine the data directly with corollary data acquired from the ground or other data sources.

The requested funds are needed to study the architecture necessary to bring all of these data sources together, catalog them, standarize the formats, and make the data available to investigators.

Dr. FROSCH. We are facing a situation of this type: We are using Landsat; we have a set of weather satellites; we have heat capacity mapping; and we have a number of other remote sensing systems. They do not all use the same data processing system, or the same data format, or even the same geographical set of coordinates.

If you ask a single question, you can get a large collection of data with different characteristics, which frequently makes it difficult for a user to use the data.

We would like to begin to put these data in the same format, and have a system so that if you ask for all of the remote sensing information, for example, about a particular place, you get it in a compatible, usable form.

I hope that eventually we can include other forms of geographically indexed data in the same kind of system.

SHUTTLE/SPACELAB MISSION DESIGN AND INTEGRATION

Mr. BOLAND. On RD7–41, the Shuttle/Spacelab Mission Design and Integration, you are requesting $8,300,000, as against $6,400,000 for the current FY 1979 estimate. That is about $2,000,000 over the 1979 level. I notice that last year you indicated you dropped the amount by about

$500,000 because of the rephasing of activities consistent with the delay in the near-term Space Shuttle missions. Is the 1980 budget estimate based on the first projected launch date of September 28 or the second of November 9?

Dr. CALIO. These figures are based on a November 9 launch.

SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT

Mr. BOLAND. On RD7–49, the justification discusses the Shuttle/Spacelab payload development for the materials processing activity. The request for 1980 is $10,800,000 compared with $12,400,000 in 1979. This, I understand, was an area of high hopes, and one we expected might lead to manufacturing in space. I understand that the thrust this year has been changed somewhat, and that you are looking more at basic research rather than applied research; is that correct?

Dr. CALIO. It is a combination.

Dr. FROSCH. We at NASA and a National Academy of Sciences review committee concluded that the basic science for some of the proposed manufacturing products simply had not yet been done, and that we have to go through a phase of more basic and applied science before we can talk about real manufacturing.

Mr. BOLAND. So when you get to that phase you will talk about real manufacturing?

Dr. FROSCH. Yes.

Mr. BOLAND. How does this work?

Dr. FROSCH. We have some discussions of real manufacturing going on now. There are some industrial firms that do have some potential products that interest them and they are interested in participating in the program. But most of it is still in the research and preparatory stage.

Mr. BOLAND. In view of that change of emphasis, how are private companies going to get into the space manufacturing business?

Dr. FROSCH. First, I think we have to have scientific indication that there really are products. Then we would expect to have them engage in cooperative research with us, using Spacelab facilities. That effort could lead to enough assurance on their part that there really was a commercially viable product. Then we would expect them, in essence, to build facilities and buy Spacelab flights. The first stage will be cooperative research.

Mr. BOLAND. What type of space manufacturing would be done? I am just wondering if this idea has been oversold.

Dr. FROSCH. That is one interpretation of shifting back from talking about manufacturing products to talking about research and development. I can mention the two products which private companies have been particularly interested in. Other products may be possible.

One interest is in the purification of some biological products for pharmaceutical use where the manufacturer believes that his process on the ground is disturbed by convection and mixing, caused by gravity. The manufacturer believes that a non-gravity environment would improve the product. Since the product is small in volume and weight, but extremely valuable, he thinks there is a possibility that processing in space could be profitable.

The other is in the manufacturing of latex microspheres of a particular size and quality, which are used as test objects in certain kinds of industrial and scientific products. Again, it is impossible to manufacture the appropriate product on the ground because of mixing and gravity. It could be manufactured in space. It has the properties that it requires small quantities of raw materials, can be produced and marketed in small quantities, and is very valuable. It might be possible and profitable to manufacture in space.

The glass industry, in particular, also has some interest in manufacturing glass by containerless processing, because the chemical interaction between the melt of glass and the surface of the container tends to pollute the glass mix. Under near zero gravity conditions one can suspend the materials away from the container in a vacuum and make the glass. The question is, "Can one use space processing to achieve advances in glass chemistry that are valuable?" That is what we have to find out.

It is believed that there are metallurgical products, alloys, which cannot be made in the presence of gravity because the materials separate too rapidly from the melt so that they never alloy. However, under near zero gravity conditions, there would be no gravity forces to separate them, so one might construct materials that can't be even tried on the ground. Since we have never made them, we don't know, other than theoretically, what the properties of such materials would really be. There are suggestions that you could make some materials that would be very valuable: we need to conduct small-scale experiments to demonstrate a) that they can be made, and b) that they really have properties that are valuable.

Mr. BOLAND. And this shift from applied research to basic research really is the result of the decision by NASA? There was no pressure from outside sources?

Dr. FROSCH. No, we did have the assistance of a report from the National Academy of Sciences that suggested the shift, and this is also our view. I would really characterize it as a shift from trying to plunge directly into pilot plant manufacturing to doing more basic and applied research.

Mr. BOLAND. You could have arrived at this decision last year.

Dr. FROSCH. Yes, we could have, but we didn't.

Dr. CALIO. In this regard, we have experimental facilities.

Dr. FROSCH. Yes, these facilities will enable us to do these experiments on Spacelab missions.

Mr. BOLAND. If you had the extra money, you wouldn't put it into this program, would you?

Dr. FROSCH. I don't think we would put a significant amount of it into this effort in FY 1980.

AERONAUTICS AND SPACE TECHNOLOGY

Mr. BOLAND. Let us turn to the Aeronautics and Space Technology section of the justifications, on page AST–1. You are requesting $419,700,000 in 1980 as compared with $376,400,000 in 1979. What was your request to OMB for this activity in 1980? What new starts were proposed to OMB, and what did OMB cut back on?

Dr. KRAMER. Mr. Chairman, our total FY 1980 Aeronautical Research and Technology request to OMB was $326.5 million. The reductions included deletion of an expansion of our Research and Technology Base activity, in the amount of $12 million; deletion of a focused technology effort for advanced rotorcraft, in the amount of $11.2 million; and deletion of funds in the amount of $3 million for advanced propeller research.

Mr. BOLAND. What sort of a program is this?

Dr. KRAMER. The advanced propeller research request was concerned with two general kinds of applications. One would have been in the relatively high subsonic Mach number regime—in the neighborhood of .7 to .8—much like the transport aircraft that you and I would fly in. The other was aimed at extending the application of advanced airfoil technology to propellers in the very low speed range, on the order of 150 to 200 knots for general aviation type aircraft.

Dr. FROSCH. The point is that we believe with appropriately designed turboprops, one can go at nearly the speed of a jet fan aircraft with considerably improved fuel efficiency, provided that we can solve some problems of noise in the cabin. We have some ideas on solving them, but not a definitive solution.

Lack of those FY 1980 funds does not mean we have no research program; it means that we could not expand that program in the direction that we would like to have done.

Dr. KRAMER. All three items were in the latter category. We have ongoing activities in those areas, and we were trying to augment them.

Mr. BOLAND. With respect to the ZBB concept, how would you characterize aeronautics in the 1980 budget request? Is it at a minimum level, a current services level, or an improved level?

Dr. KRAMER. It is at the current services level.

Mr. BOLAND. I think we asked the same question last year, and you indicated that it was at the improved level. It improved over 1978?

Dr. FROSCH. That is correct. The 1980 request is the current level, which means that the money requested is necessary to continue the ongoing program.

Dr. LOVELACE. I might point out that that figure is the Aeronautics Research and Technology; it does not include the Space Research and Technology and the Energy Technology programs. Our total request to OMB for those three line items was $468.7 million. That compares with $419.7 million in the President's budget.

PROPULSION SYSTEMS TECHNOLOGY

Mr. BOLAND. On pages RD 9–21, 22, and 23, the legend discusses the Propulsion Systems Technology activity funded at $20,600,000 in 1980, down from $28,400,000 in 1979. On page RD 9–22, in the fifth paragraph, there is a discussion of the variable cycle engine. That is really part of or goes along together with the supersonic transport program. Is that correct?

Dr. KRAMER. A future supersonic transport program would benefit substantially from successful development of the technology for a variable cycle engine, but our variable cycle engine technology has applications to vehicles other than supersonic transport.

Mr. BOLAND. How much of the $20,600,000 is allocated to that program?

Dr. KRAMER. To variable cycle engine technology?

Mr. BOLAND. Yes.

Dr. KRAMER. In FY 1980, it is planned at $5 million.

Mr. BOLAND. Is that a program in which you would want to put more money?

Dr. KRAMER. It is a systems technology program with a finite funding profile for a range in time. I am sure we will want to extend that activity into FY 1981, whereas at this time we have no funds in the program beyond FY 1980.

Mr. BOLAND. On the page RD 9–23, the advanced turboprop program is discussed in the third paragraph. How much of the $20,600,000 is allocated for that program?

Dr. KRAMER. The turboprop effort is planned at $2.8 million in the FY 1980 budget estimate. We had sought to enhance that effort, as we discussed earlier, by $3 million.

Mr. BOLAND. You indicated that you had requested more for this program; how much more?

Dr. KRAMER. We requested $3 million in addition to that $2.8 million. We were at $3.2 million in Fiscal Year 1979; we were attempting to build this effort up to $5.8 million in Fiscal Year 1980, but we are at the $2.8 million level.

Mr. BOLAND. On RD 9–29 we find an item known as High-Performance Aircraft Systems Technology at $16,580,000 in 1980, as against $11,060,000 in 1979. Is this the line item that used to be known as the supersonic cruise technology?

Dr. KRAMER. We have restructured our work breakdown within the Aeronautics Research and Technology program. This type of funding for systems technology now includes supersonic cruise research, plus some work on VTOL technology and advanced flight experiments, which we would conduct at our Dryden Fight Research Center. The total of $16,580,000 for those three items includes supersonic cruise research at a level of $9.7 million in FY 1980.

Mr. BOLAND. How much of the total Aeronautics budget is dedicated to supersonic transport technology?

Dr. KRAMER. Less than 5 percent of the Aeronautics Research and Technology budget. The precise number in FY 1980 planned for supersonic cruise research and variable cycle engine technology is $14.7 million. That represents about 4.9 percent of our Aeronautical Research and Technology budget request for FY 1980.

Mr. BOLAND. I am looking at that figure of $16,580,000; is it all in that figure?

Dr. KRAMER. No, Mr. Chairman, the $14.7 million is not all in that figure. The $14.7 million includes the work on the variable cycle engine technology, which is under Propulsion Systems Technology.

Mr. BOLAND. Is it the position of NASA that we ought to continue research in the area of supersonic transport technology on the basis that someday we might build an SST?

Dr. FROSCH. We at least ought to continue the technology so that we know what qualities could be built into such an aircraft at any given time. We may come to a point where it is clear that the qualities would merit undertaking such a program.

Dr. KRAMER. I would also like to point out that the technology associated with supersonic cruise capability also has military application which is finding increasing interest.

Mr. BOLAND. Is the Air Force looking at this, too?

Dr. FROSCH. The Air Force looks at related technology.

Dr. LOVELACE. I think the research and technology effort applies to our traditional role of fundamental aerodynamics in that flight regime.

Dr. KRAMER. The same thing is true in the variable cycle engine technology, where we cooperate with the Air Force because of their interest in advanced propulsion systems.

Mr. BOLAND. On RD 9–32, the Experimental Programs are described, and on the same page we find the energy efficient engine, which is funded at $55,600,000 in 1980. Last year you indicated that the total cost of that program, in 1979 dollars, would be about $184 million. Adding the figures up on the line, we get a total, through 1980, of $160.4 million.

Has the total cost of this project increased?

Dr. KRAMER. The funding has been brought up to FY '80 budget dollars. The total estimated cost in constant year dollars is the same as before. In our FY '80 budget dollars, it is $193 million.

COMPOSITE PRIMARY AIRCRAFT STRUCTURES

Mr. BOLAND. We will turn to RD 9–34. The justifications describe the composite primary aircraft structures technology program. You request $16.4 million in 1980 as against $20 million in 1979. The total cost of the program for 1980 appears to be about $80 million. What is the anticipated total cost of this program?

Dr. KRAMER. Again, in FY '80 dollars, the estimated cost is $106.6 million, which is the same as last year, except for the inflation adjustment.

Mr. BOLAND. We have had some input to the staff that this may not be the kind of a research program that should be funded through research conducted by NASA. I gather that the thrust of that argument is that NASA should think more seriously about going back to the original concept of the NACA, which was to perform more fundamental research in aeronautics. This kind of a program is more of a fabrication effort, isn't it?

Dr. KRAMER. At the beginning of the program there was a focus on characterizing the materials, developing design techniques, and testing material properties under a broad range of conditions to establish the basis for the design of certain aircraft parts, which were then fabricated for test purposes.

Dr. FROSCH. I think we could easily find ourselves falling between two schools, and I have been in that position before. If we confine ourselves only to the basic research, then the argument I have been given in these areas is that the basic research is useless because it is never carried through to the point where industry picks it up; it doesn't get into industry so let us not do the basic research. On the other hand, if you carry the effort all the way through, the argument is that industry ought to do all of that; you ought to confine yourself with the basic research.

What we try to do is to bridge the two. We start with the basic research. If the basic research produces something that looks as if it

ought to go to industry we begin to work with industry to introduce the technology and they gradually pick it up and carry it on. We have begun to do that with the use of composite materials.

We first introduced, experimentally, some of the uses of the material in interior non-structural parts. Now we are essentially almost out of that effort, and the industry has begun to incorporate that technology into the aircraft. Gradually the whole effort will move over to industry. We are providing the technology foundation.

Mr. BOLAND. As one who has been familiar with basic and applied research over the years, are you concerned over the diminution of funds in the basic research area by Government and private industry? Private industry, apparently, is pulling away more and more from it. I can't tell you how much; maybe you can tell me.

Dr. FROSCH. I don't remember the figure but it is considerable. I think they have pulled away from it too much. What worries me is that it is not only basic research that industry has pulled away from, it is applied research, too. The whole question of innovation and basic research, both in industry and Government, has become a serious issue. I think the U.S., over the previous decade, allowed both to decrease too much, both in Government and in industry. We begin to lose our competitive edge.

Industry blames Government in terms of regulations, and environmental requirements, and takes the position that they have had to do more of what they call defensive research. There may be some validity in that viewpoint, but in my mind, it has also been a convenient excuse to put money into short-term gain areas and neglect some of the long-term risk areas. I think some of the companies have begun to realize that this neglect may not have been such a good idea.

Mr. BOLAND. They are coming to that realization rather slowly, aren't they?

Dr. FROSCH. I think it depends on how much competition they have. My feeling would be that some of the industrial areas that are beginning to feel the pinch of foreign competition are realizing that they have been overtaken technologically.

TRACKING AND DATA ACQUISITION

Mr. BOLAND. Let's turn to RD 12–1, Tracking and Data Acquisition. You are requesting $332,800,000 in 1980 as compared with $302,000,000 in 1979. How is this budget request tied to the actual Shuttle launch schedule?

Dr. SCHNEIDER. Basically, we included in this budget our requirements for support of the Shuttle schedule, mainly in bringing up the communication circuits.

Mr. BOLAND. Yes, but on which projected launch schedule?

Dr. SCHNEIDER. On the schedule for this coming fall. We had to bring our circuits up somewhat sooner so that the preparations for the launch can go on. Some of the circuits are already in place.

Mr. BOLAND. I notice, on page RD 12–4, that there is a definite relationship. It is alluded to in the section on the reasons for changes from the Fiscal Year 1979 budget estimate to the current estimate. If the Shuttle slips six to nine months beyond November 9, how would this impact the Tracking and Data Acquisition budget?

Dr. SCHNEIDER. We have a number of communications lines that we have to bring up from the remote sites in order to bring the data back. If there is a slip in the Shuttle schedule prior to making arrangements for the lines, we would delay that as we did last year. However, frequently it is necessary to contract for those services before a slip is known and it is cheaper to continue the contract than to pay a termination cost. Some of the lines, as I said, are already in place as we go through the process of preparing for the launch.

Mr. BOLAND. On page RD 12–7, you indicate that Shuttle orbital flights projected for Fiscal Year 1980 will incur some additional network support costs. How much will this add based on a November 9 launch and how much based on a May 1980 launch? You can supply that for the record if you don't have it.

Dr. SCHNEIDER. I will supply that information for the record.

[The information follows:]

Question. I noticed on page RD 12–7 you indicate that Shuttle Orbital Flights that are projected for fiscal year 1980 will incur some additional network support costs. How much based on the November 9 launch and how much would they be based on a May 1980 launch cost?

Answer. The additional network support costs (staffing for air to ground voice communications and TV systems at the stations) contained in the FY 1980 budget request are approximately $1,000,000 greater in FY 1980 than FY 1979 based upon a November date for the first Shuttle launch. Due to the leadtimes involved in the training, testing, and checkout of personnel on the equipment and operating procedures, a large portion of these costs are already being incurred in preparation for the November launch date. Therefore, the additional costs for network support in FY 1980 would be approximately $700,000 or a savings of $300,000 from the budgeted level with a delay in the first shuttle launch from November 1979 to May 1980.

Mr. BOLAND. All right. On pages RD 12–16 and RD 12–17, the justifications describe the basis for the Fiscal Year 1980 estimate for Spaceflight Tracking and Data Network systems implementation. Are these funds, $17 million, directly related to implementing the Tracking and Data Satellite System, TDRSS?

Dr. SCHNEIDER. No, sir. As you recall, the TDRSS is a service contract and payment does not begin until the service is started. Service will be started after the first spacecraft is in orbit for one or two months so the funds will be included in next year's budget.

Dr. FROSCH. It does include some of the ground work and support that we need in order to prepare for TDRSS.

Mr. BOLAND. As I understand it, the TDRSS will be the first satellite flown on an operational Shuttle mission—on flight number 7. Is that correct?

Mr. YARDLEY. That is correct.

Mr. BOLAND. If the Shuttle launch slips from the November target date to May, how does that impact the requirement for these funds?

Dr. FROSCH. I think this is basically capital investment and it would not be affected very much by that kind of slip.

TRACKING AND DATA RELAY SATELLITE SYSTEM (TDRSS)

Mr. BOLAND. Let's get into the TDRSS program a bit. Would it be fair to say that this program experienced one of the most bizarre goofs that NASA has had?

Dr. FROSCH. It is certainly a difficult one. It has been very painful.

Mr. BOLAND. It was an experience that was probably the most bizarre that NASA has had in its 20 years of existence. The contract for this satellite system, which will replace the existing ground stations for low earth orbit communications, was awarded to Western Union Space Communications Company in an amount of $796,000,000, a fixed-price contract. That contract has recently experienced an $80,000,000 overrun because of the necessity to redesign the system to withstand unforeseen radar interference from the large Soviet radar installations in Eastern Europe. They say that the radar interference was not foreseen, but that really isn't so, is it?

Dr. FROSCH. It was known at the time of contract.

Mr. BOLAND. Did NASA fail to inform the contractors about the classified data it had on the Soviet early warning system?

Dr. FROSCH. As far as I can tell, by going back and trying to understand what happened, it was known in NASA that there was a problem. A decision was made that rather than putting a classified attachment to the contract that would describe it in detail, an unclassified portion of the specifications would be written to cover the requirements and that was included in the contract.

As far as I can tell, it was known in NASA and it was also known to the subcontractors building the spacecraft what the nature of those interfering sources were.

I would say there turned out to be several factors: one, the intent of the unclassified specification was not completely satisfactory; two, the contractor's internal communications as to those who had the classified information and those who needed the classified information was not satisfactory. NASA did not repair that situation by entering into the communication, partly because of the nature of the contract which left us, even in the negotiations, feeling that we were in a very uncomfortable "arms distance" kind of situation. If it had been a different kind of contract, we might have operated differently in that case.

Mr. BOLAND. When you declassified a portion of the contract, why didn't you whisper it into Western Union's ear?

Dr. FROSCH. There was some whispering of that kind going on but I am not sure that it was sufficient.

Mr. BOLAND. Who was in charge of the contract? Who was responsible for the negotiations with Western Union? Any particular individual?

Dr. FROSCH. The contracting officer is at the Goddard Space Flight Center but it has been a Headquarters and Goddard arrangement with Western Union and TRW.

I don't think it was really a failure of contract negotiation so much as a conscious effort to do it in a particular way which failed. Bill, do you want to add to that?

Dr. SCHNEIDER. No, I think you stated it quite properly. We tried to paraphrase the highly classified data in an unclassified document which was included with the request for proposal. Classification in performance specifications is a major problem. In retrospect, it was not properly included in the specifications. It was included in a document in the reference library. Having the service contract, which prohibits us from having direct eyeball contact with the contractor, made it such

that we didn't uncover this until we reached a major design review.

Dr. FROSCH. Even then, there was a sequence of rather confusing events. It was first believed that a very expensive redesign of part of the system would have to be undertaken to meet the requirements. It was then determined that, even while that was going on, there was test data at the manufacturer which demonstrated that extension of a redesign was not required but that something simpler was required. As a result, we had that complication added to the negotiation of what had to be done about it.

Mr. BOLAND. TRW is building the satellite, is that correct?

Dr. FROSCH. That is correct.

Mr. BOLAND. They are not exactly babes in the woods in building satellites, are they? I would think they could have people who are knowledgeable in this area and they would recognize and know of the existence of the Russian radar.

Dr. FROSCH. There is no question about it. I think if it is fair to say that we should have been whispering in their ear more, then it is also fair to say that they should have been asking more questions about the specifications because they were the subcontractors on a performance specified contract. They are not innocent in the area, as you stated, and should have been alert to the fact that there was something that they needed to ask about.

Mr. BOLAND. Is it correct to say that, even after the changes are made, Soviet radar interference with TDRSS will remain?

Dr. FROSCH. It will mean that there is a small area over Eastern Europe where we will not be able to use TDRSS.

Dr. SCHNEIDER. That is correct. Whenever the spacecraft being served is in a direct line between the TDRSS spacecraft and a ground base emitter, it will interfere with the service.

Dr. FROSCH. I would like to add that one of the considerations in the negotiation of the solution to this problem was whether it was worthwhile spending the money in the contract to overcome that difficulty. Our conclusion was that it was a sufficiently small modification to the service that is not worth a great deal of effort and money to fix.

Mr. BOLAND. Did the contractor pay for part of the goof?

Dr. FROSCH. In effect, we believe that the negotiation results are to share the costs.

Mr. BOLAND. What type of time range does the contract provide for?

Dr. SCHNEIDER. The service contract runs through ten years.

Mr. BOLAND. When this was first proposed it was done on the basis that the cost would be handled by the Federal Financing Bank, so that takes it off-budget, of course. From the standpoint of the appropriations process, I think this is a classic case of why we should not have acceded to the concept of placing this program off-budget. The cost of $80 million will be funded through the Federal Financing Bank essentially without any Congressional control. This Subcommittee has put at least one of the programs that I am aware of on-budget through legislation in the Appropriations Bill. Would you have any objections if we did that here?

Dr. FROSCH. I am not certain how that would be done technically.

Mr. BOLAND. If it is in the Legislative and Appropriation Bills, then

I think we can do it. We have done it before. You didn't give me an answer to that question. We would have better control on-budget, wouldn't we, Bill?

Mr. LILLY. You certainly would be the one to determine that.

Mr. BOLAND. Is there any problem if we put this on-budget rather than being financed through the Federal Financing Bank?

Dr. FROSCH. Do you mean appropriations of funds directly?

Mr. BOLAND. Yes, directly.

Dr. LOVELACE. It would clearly change the nature of the contract. If we were going to maintain the schedule, we would probably have to come back in for a supplemental in order to maintain the schedule.

Dr. FROSCH. Yes, there would be a question of the phasing of the funding and how to do it.

Mr. BOLAND. Larry, do you have any questions?

Mr. COUGHLIN. Thank you, Mr. Chairman. I apologize that I have been absent from a major part of the hearing. I have only one question and that is a follow-up to a question from the Chairman this morning. You have already indicated that $27 million will be needed for the fifth orbiter option in Fiscal Year 1980. I also understand you said the option would exist even if no money were included, but that it would be more expensive. Could you provide for the record a chart on the cost of the fifth orbiter if no funds were included in Fiscal Year 1980?

Dr. FROSCH. We can certainly provide that.

[The information follows:]

The additive cost to the FY 1980 budget submission for the fifth orbiter starting in FY 1981, if no funds were included for FY 1980, in dollars of the FY 1980 budget is as follows:

	Millions
Fiscal year 1981	+27
Fiscal year 1982	+148
Fiscal year 1983	+179
Fiscal year 1984	+170
Fiscal year 1985	+108
Fiscal year 1986	+18
Total	+650

Mr. COUGHLIN. Thank you and I apologize for missing part of the hearing.

Mr. BOLAND. That ends our review of Research and Development. The Committee will stand adjourned until 10:00 a.m. tomorrow.

THURSDAY, MARCH 8, 1979.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. BOLAND. The Committee will come to order. We will take up Volume II, Construction of Facilities. The request for FY 1980 for all of the centers and locations is listed on page Sum 4. The request is $157,600,000 as opposed to the $147,000,000 in 1979. This is an increase of about $10 million above the 1979 level.

CONSTRUCTION OF FACILITIES REQUEST TO OMB

What was the NASA request to OMB for Construction of Facilities in the 1980 budget?

Mr. MCGARVEY. Sir, $174.9 million was the total request. The reduction was $17.3 million.

Mr. BOLAND. Last year you indicated that two specific projects were deleted by OMB. One project cost $2.2 million and was for a flight experiment facility addition proposed at the Ames Research Center for Life Science Experiments, and the other was $5.9 million for a Spacelab Data Facility addition at Goddard.

Are either of these in the 1980 budget?

Mr. MCGARVEY. The first one, at Ames, is in the budget under the Payload Facilities. It is in the budget request on page CF 11–14, for

$1,640,000, which is an addition to the Materials Sciences Laboratory that we are proposing.

Mr. BOLAND. This is an addition to it?

Mr. MCGARVEY. Yes, sir. This is a modification of existing space and an addition to the building to take care of development of experiments for Spacelab payloads.

Mr. BOLAND. Is the facility the same as the facility that you were talking about last year—the one that was deleted by OMB for $2.2 million at Ames? You have $1,640,000 budgeted for this in 1980. Why is there such a difference?

Dr. FROSCH. Instead of having a whole building, they are building an addition to the existing Materials Sciences Laboratory and modifying part of the facility at a slightly lower cost, but to do the same work.

Mr. BOLAND. All right. Did your request to OMB include the $5.9 million for the Spacelab Data Facility at Goddard? Was that one of the items that was dropped in the OMB reduction of $17.3 million?

Mr. MCGARVEY. Yes, sir.

CONSTRUCTION OF FACILITIES FULL FUNDING

Mr. BOLAND. We talked about full funding for particular programs and projects yesterday. What about full funding of construction of facilities? We do it with the VA, and we do it with other areas. Would you like that?

Mr. LILLY. Mr. Chairman, we do, as a practice, fully fund facilities that are readily definable, such as office buildings or any other facility that is not dependent upon actions of research and development to move along.

Incremental funding is only used for the large facilities which are dependent on the articles to be tested, such as the Shuttle or items where specifications change as you move along; we find and believe it is more efficient to fund those activities based on what we define year by year, rather than the total at one time.

Mr. BOLAND. It puts you in a better position if there is a big overrun, doesn't it?

Mr. LILLY. That could be the case, however, Mr. Chairman, as you know, we have performed quite well on these.

Mr. BOLAND. You have been marvelous. NASA is one of the best agencies in the Government on these activities. I keep telling this to other agencies we have—to VA, HUD, etc.

Mr. MCGARVEY. Sir, it has an added advantage from a parochial viewpoint of an Agency with a fairly constant level Construction of Facilities (C of F) budget. Over the years, we have averaged $150 to $160 million in the C of F program. If we are hit with some large funding requirements for a large research or test facility in a single year, this almost puts us out of business in taking care of the other valid requirements because of the cost of the large-scale facilities. This also enables us to request only the funding which we can put to work and obligate during that fiscal year. We think it is a very prudent way to manage a very large, complex facility in support of our R&D requirements.

NASA FOCUS ON ENERGY SAVING PROJECTS

Mr. BOLAND. Looking over some of the projects you propose for the various centers, it appears that there has been a conscious effort to select a number of smaller projects, many of which are directly concerned with energy saving. Is that merely coincidence, or was there a conscious effort made in that direction?

Mr. MCGARVEY. Yes, sir, there was a very conscious effort made in that direction, and I might also add that in the OMB cut, we did lose some other proposed major energy investments. We lost six energy projects for which we were asking $7.9 million. We did have additional energy projects, although the present program is balanced in that we have included $11.2 million in energy-saving investments.

There are three in the major category of discrete items, and 22 smaller ones in the rehabilitation and modification program.

SPACE SHUTTLE LAUNCH PAD B AT KSC

Mr. BOLAND. We will turn to the Space Shuttle Facilities on page CF 10–1. You are requesting $31,450,000 for the continued construction of Shuttle facilities at various locations. On page CF 10–5, the justification outlines the request of $17,700,000 for the continued modification of Launch Complex 39.

Last year the Committee recommended that the second phase of Pad B of Launch Complex 39 at the Kennedy Space Center be delayed for a year. Let me quote from last year's justifications,

"The requirement for Pad B to be operational by not later than early 1983 is a critical milestone for the Shuttle operations."

This year's justification on page CF -0–6 states,

"December 1983 is thus the latest acceptable operational ready date for Launch Pad B and is a critical milestone."

It appears that the critical milestone of last year, which was early 1983, has slipped to December 1983, almost a full year. It appears that the Committee's recommendation last year was based on reasonable rationale, wouldn't you agree?

Mr. MCGARVEY. Yes, sir.

Mr. BOLAND. Let me quote again from the Committee Report,

"The Committee suggests that the second phase can be delayed one year because the twelve year mission model has been decreased from 560 to 487 flights and the first flight of the Shuttle appears to be slipping from six to nine months."

The $12,800,000 for the second phase of Pad B was ultimately restored to the budget in 1979. That $12.8 million was supposed to buy us a ready operational Pad B by early 1983. Why has that now slipped to December, 1983?

Mr. MCGARVEY. Originally we had $27.1 million in FY 1978 resources that were to be applied to Pad B. We had to reallocate some of that funding last year due to later needs that were associated both with mobile launch platforms, and the need for changes in the Vehicle Assembly Building. We also had to reallocate some of the funding to Pad A.

But the $12.8 million that was appropriated for 1979 and the $15.1 million included in this request really goes to Pad B and will permit us to complete Pad B by late 1983, the required operational date. Part of the slippage is due to the reallocation of funds to higher priority items that occurred last year, and the other, of course, relates to some slippage in the Shuttle launch date.

Mr. BOLAND. The third paragraph on page CF 10–7 explains, as you have indicated, the reason the increase to $15.1 million is required is to complete the work, but it appears from this paragraph on CF 10–7 that NASA did precisely what the Committee recommended. It took funds appropriated for the construction of Pad B from 1978 and 1979 and used those funds for other purposes and basically, you delayed the construction of Pad B from the beginning of 1983 to the end of 1983 or about nine to twelve months, which is what the Committee recommended could be done on the basis of the Shuttle slippage, and on the basis of the flight rate. Is that correct?

Mr. MCGARVEY. In effect, that is what we did; that is what took place.

Mr. BOLAND. I thought I was going to get an argument on that. At the time, we were considering the possibility of delaying the second phase of Pad B for one year, but you indicated that the contract for the rotating service structure could not be phased into two packages without extreme difficulty; but isn't that what you have actually done?

Mr. MCGARVEY. Yes. Part of the rotating service structure is being provided with FY 1979 funds and we were able to break it into work packages so that the $8 million requested this year will complete the rotating service structure.

Mr. BOLAND. We don't always seem to get straightforward answers when we ask certain questions about the need for construction projects within a particular time frame. Perhaps you can't always give an absolute time frame—or can you?

Dr. FROSCH. I think we have difficulty in always being sure exactly how the work can be phased.

Mr. MCGARVEY. I think, Mr. Chairman, it is difficult from the standpoint of a development program to give you a precise answer. As an example, we have had required changes to the mobile launch platform. We have had to make changes to increase their structural strength.

Mr. BOLAND. That would affect the time frame, of course.

Mr. MCGARVEY. Yes, sir. It affects the time frame, when you have to make those changes. And we have had some adjustments primarily because, as the system develops or evolves, it has a direct impact on the facilities, and we have had to adjust the facilities accordingly.

MAXIMUM FLIGHTS PER LAUNCH PAD

Mr. BOLAND. Last year we asked General Curtin what the maximum number of flights is that can be operated from one pad in one calendar year. The answer given was from 20 to 23. That, I think he indicated, was a realistic figure.

On page CF10–6, of this year's justifications, in the second paragraph, you state that during the operational phase, the risk of having

only one launch pad in the early years is conditionally acceptable. What are you talking about when you say "conditionally acceptable?"

Dr. FROSCH. We are taking the chance.

Mr. BOLAND. Should you?

Mr. LILLY. There are two reasons. One, in terms of the launch rate itself, you need a second pad. The other is that we are very much interested in having the second pad as early as possible to avoid a single point failure in terms of any catastrophy that might occur.

Mr. YARDLEY. Could I interject something here? It is becoming more apparent that more payloads, particularly Department of Defense payloads, are going to require more pad time than standard ground turn-around allows. This means that you can't get 23 flights in if we have a few of those flights that require two to three weeks extra.

Mr. BOLAND. Are 20 flights from one launch pad conditionally acceptable?

Dr. FROSCH. Yes, certainly in the early few years.

Mr. BOLAND. How about 23?

Dr. FROSCH. We probably can do 23. John, where would you say the cut-off in the number of flights is?

Mr. YARDLEY. I am nervous about the 18 we have scheduled for Fiscal Year 1983.

Dr. FROSCH. From the pad point of view, or from the ground turn-around time?

Mr. YARDLEY. From the ground turn-around time. There are two factors. One is that we probably are not going to be able to launch on a realistic basis, more than 18, based on the types of missions planned. The other point, of course, is that any sort of damage, even the most minor, would tie us up for two or three weeks and slow down the whole program.

Then, if there were a major catastrophy, it would cause long slips.

Dr. FROSCH. Part of the problem is predicting how something we have never done before is going to work and the related question of whether there will be problems that will cause damage to the pad that even temporarily will put it out of action. With one pad, it is a single thread, single failure kind of system.

Mr. BOLAND. As I recall last year NASA indicated that Pad B was required by early 1983. Is that correct?

Mr. YARDLEY. That is correct.

Mr. BOLAND. That is what you told us last year, and of course the Committee accepted that and acted on that basis, too.

AMES RESEARCH CENTER STATIC TEST FACILITY

We will turn to CF 1-2, the Ames Research Center where you are requesting $2,900,000 for modification of the static test facility.

You indicate on CF 1-3 that rotorwhirl testing is presently restricted to turbo-driven models, but that many current and near future model advanced rotor systems require electronic motor drive for this type of testing. You indicated an alternative to performing these whirl tests at the static test facility would be to use a test section of a 40-by-80 foot wind tunnel.

How has this type of testing been accomplished to date?

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Dr. KRAMER. This kind of testing, to the extent that we are able to do it, is at the present time limited in the number of degrees of freedom. It is either done in a cleared area outside of the 40-by-80 foot tunnel, which has come to be known as the static test facility, or in the 40-by-80 foot tunnel with the wind off, because of the availability of power sources inside the 40-by-80 foot tunnel, and also because of the need for the proper kind of handling equipment for the large scale test devices.

The idea behind this upgrading of the rotor-static test facilities is bringing in the variable frequency power, which permits a more accurate speed control. For example, the provision for full degree simulation is to stop using the 40-by-80 foot wind tunnel test section for that purpose and to allow it to be used more productively for actual wind tunnel purposes, rather than just static testing purposes.

Mr. BOLAND. Regarding the type of testing you have been describing, how often has that approach been utilized?

Dr. KRAMER. How often in the 40-by-80 foot tunnel?

Mr. BOLAND. Yes.

Dr. KRAMER. I don't have that number with me. But we would be happy to supply it from our historical record.

[The information follows:]

Approximately 500 hours per year are used for setting up and checking out rotor systems in the 40x80-foot wind tunnel. Of this amount, 335 hours per year are spent for calibration of the rotor system and instrumentation, and this is roughly the amount of extra time per year that could be used in the 40x80-foot wind tunnel if the static test facility were available.

DRYDEN FLIGHT RESEARCH CENTER AIRCRAFT MAINTENANCE DOCK

Mr. BOLAND. We will turn to the Dryden Flight Research Center, page CF 2–2, where you are requesting $1,500,000 for the installation of a large United States Air Force surplus maintenance dock, which is a hangar, I presume.

On page CF 2–4, the justification indicates that the Center has no facility of sufficient size to accommodate a large aircraft. You also indicate on that page that the Shuttle hangar was sized specifically to accommodate the Space Shuttle. Consequently, the width of the Shuttle hangar door is only 137 feet. It cannot accommodate aircraft of larger wingspans, like the B–52, which has a wingspan of 185 feet.

Do you recall the issue that developed over the construction of a Shuttle hangar about four years ago?

At that time, NASA indicated that a Shuttle Hangar was absolutely vital because a Shuttle had to be housed indoors and could not be permitted to stand in the weather outside. As a matter of fact, during the approach and landing tests when Orbiter 101 was at Dryden, it was only inside the hangar for about five or six weeks. The balance of the time it was sitting outside, often on top of the 747. So, what you told us last year didn't hold true, did it? Is it true that the Shuttle has been outside practically all year?

Mr. YARDLEY. Mr. Chairman, the big difference between the Approach and Landing Test Shuttle's ability to stay outside and the

operational Shuttle is that we don't want to get moisture on the thermal protection system if we can possibly avoid it.

With an operational Shuttle we try to have it under roof cover as long as possible. When we do have to take it outside sometimes, we need to guard against rain.

Dr. FROSCH. The Orbiter 101 test vehicle does not have real thermal protection tiles on it. It has simulated ones.

Mr. BOLAND. The 747 has been sitting outside and even with the new hangar, it will continue to sit outside, won't it?

Dr. FROSCH. Yes, but this is a maintenance dock we are requesting; we wouldn't maintain the 747 at Dryden.

Mr. BOLAND. All right. Can the Shuttle hangar doors be modified to permit the acceptance of larger aircraft?

Mr. MCGARVEY. I don't know, Mr. Chairman. I would have to provide that for the record. I think, though, that the overall size of the hangar will not accommodate the B–52, which is the primary requirement.

Mr. BOLAND. How about the YC–14 and the YC–15 aircraft? Can they be housed in the Shuttle hangar?

Dr. LOVELACE. I would think, Mr. Chairman, that they could. We can check that for the record.

[The information follows.]

It is not feasible or cost effective to modify the shuttle hangar doors as they currently open the full width of the hangar (door opening is 137 feet and hangar width is 140 feet). The overall size of the hangar, 140 feet wide by 175 feet long, is such that it cannot accommodate the B–52 which has a wing span of 185 feet.

The YC–14 and YC–15 aircraft can be housed in the shuttle hangar. However, because Dryden Flight Research Center is the designated secondary recovery site for Space Shuttle operational flight programs, the use of the shuttle hangar would be limited. During shuttle flights, the hangar must be available on short notice to accept the Orbiter in case of a contingency landing.

Mr. BOLAND. What about the B–52 that has been sitting outside since it arrived at Dryden 15 or 20 years ago?

Dr. FROSCH. Again, I don't think it has been maintained outside, not full major maintenance.

LYNDON B. JOHNSON SPACE CENTER FLIGHT OPERATIONS FACILITY

Mr. BOLAND. Turn to CF 3–2, where you are requesting $1,760,000 to rehabilitate and modify the flight operations facility at Ellington Air Force Base, near the Lyndon B. Johnson Space Center. On page CF 3–6, the various details of the construction project are outlined. Some of those items appear more critical than others. What about the four motorized hangar doors costing $137,600? Does the current hangar have motorized hangar doors?

Mr. MCGARVEY. No sir, it does not. This system motorizes the doors.

Mr. BOLAND. What about the $527,400 for the installation of a fire protection system? Does the current hangar meet local fire codes?

Mr. MCGARVEY. No sir, it does not. It requires a very extensive modification in order to bring it up to meet the acceptable code and protect the investment of aircraft that we maintain in that hangar.

LANGLEY RESEARCH CENTER COOLING TOWER

Mr. BOLAND. We will turn to the Langley Research Center, where four projects are requested. On page CF 5–17, you are requesting $970,000 to replace a cooling tower.

When will the "future requirements" discussed in the second paragraph on CF 5–18 be ready for testing at Langley? The future tests require a 15,000 gallon per minute cooling capacity.

Dr. FROSCH. When will the increased requirements of 15,000 gallons per minute be an actual requirement?

Dr. KRAMAR. I cannot answer your question. A prime motivation for the cooling tower they have for the TDT is to modernize and update the tunnel in general. There is associated with that an increase in capacity.

The present existing cooling towers are in bad shape, and they are in the middle of one of the test circuits. There is some concern about fire hazards associated with the cooling towers. So an updating of this facility is necessary in order to bring it up to present day standards.

MARSHALL SPACE FLIGHT CENTER STEAM LINES

Mr. BOLAND. Turn to CF 7–2 on the Marshall Space Flight Center. There is a request on that page of $2,640.000 for modification to various buildings. The description on pages CF 7–3 and CF 7–4 indicates that you intend to replace the steam lines from the Redstone Arsenal Steam Plant to five existing buildings and substitute electric heaters.

You also indicate that modular boilers and water heaters are to be installed to replace the steam lines. This is a fairly major overhaul of the existing heating and hot water system at the Marshall Space Flight Center, is it not?

Mr. MCGARVEY. Yes, sir. We rely today on the Arsenal's central steam plant, but the steam distribution system is so deteriorated and in such bad condition that the steam losses are very large, which is a great loss of energy, and an increase in our utility bills that we pay to the Arsenal.

A study was done to determine which was most cost effective—to replace the steam distribution system, or do this type of work. This proved by far to be the cheaper route.

CONSIDERATION OF ALTERNATIVE ENERGY SOURCES

Mr. BOLAND. Isn't it a fact that the Marshall and Johnson Space Flight Centers are deeply involved in alternative energy programs?

Mr. MCGARVEY. Yes, Marshall——

Mr. BOLAND. Particularly solar?

Mr. MCGARVEY.——in particular, solar heating and cooling.

Mr. BOLAND. Did you give any serious consideration to the possibility of putting in solar collectors for these buildings at Marshall?

Dr. LOVELACE. We did not to my knowledge, Mr. Chairman, examine that alternative.

Mr. MCGARVEY. I think primarily, Mr. Chairman, the cost for doing that for this number of buildings would be very high with solar energy.

Mr. BOLAND. You have had a little experience with solar collectors at Langley, however.

Dr. FROSCH. The headquarters building at Langley and several buildings at Marshall have auxiliary solar, thermal systems that they are working with.

Mr. BOLAND. How about the facility at Langley? Is that an auxiliary system? Is that heated and cooled by solar collectors?

Dr. FROSCH. There is a specific housing unit that was built for that purpose. There is a building at Johnson which is using an auxiliary system.

Mr. BOLAND. Do you have any indication of what the energy savings have been at Langley?

Dr. FROSCH. On the single unit house we do, and someone may remember the figures better than I. My recollection is that there was something like a 40 percent saving. It was a single family house, and the saving varied with the activities of the people in it.

Mr. BOLAND. You indicated that the one at Langley is a large office building, is that right?

Dr. FROSCH. There is a demonstration house specifically built for that purpose, but there is also an office building—the Systems Engineering Building.

Mr. BOLAND. We are more interested in the office building than the house.

Mr. MCGARVEY. I don't have the exact figures here, but a percentage of the heating and cooling requirements in the Systems Engineering Building at Langley is supplied by solar. I believe it supplies about 57 percent of the heating and cooling requirements in the building.

But it does not provide all the primary heating and cooling for the building. It has a backup conventional system.

Mr. BOLAND. Is there any indication of cost or energy savings as a result of this particular installation?

Mr. MCGARVEY. Yes sir, and we can provide those for the record.

[The information follows:]

Solar energy does provide approximately 57 percent of the heating and cooling needs for this building, equating to a savings of approximately 6,090 gallons of oil per year or approximately $2,400 per year. It should be noted that the solar application in this building is a R&D test bed for the evaluation of advance collectors that come on the market. Performance data are compared between the different types of collectors and other solar concepts verified in this facility.

The data collected to date has shown that solar heating and cooling is a practical concept but is not yet economically attractive. The capital investment in the system exceeds $737,000, and would require thirty years or more to amortize on a simple payback basis.

Mr. BOLAND. I would think this would be an area where NASA would be in the forefront and attempt to use the newest kinds of alternative energy possibilities. Where possible, NASA ought to do this, if it is cost effective.

Mr. MCGARVEY. Yes, sir. To date, in the solar energy program, most of the projects have been limited to supplemental hot water heating and we have already invested about $1.5 million of our own funds. Then, in conjunction with DOE, we have a number of pending requests for both FY 1978 and 1979 funding for solar projects, which has not yet been released to us.

As an example, we have over $3 million worth of designed valid projects that are ready to go and for which we are awaiting release

of funds from DOE for demonstration projects in solar energy. These go beyond the supplemental heating for hot water purposes only.

Mr. BOLAND. Do any of the top scientists at NASA have any ideas on the effectiveness of solar power?

Dr. FROSCH. I think it is clear that the effectiveness of solar thermal for hot water heating is very high. When you inquire about the heating of a building, it really depends on how that building was built to begin with.

If you are designing a new building, then I would expect that it can be designed so that the effectiveness is high. If you have an old building and, for example, it is heated with pumped hot water, then it is likely that you can get a good contribution from solar.

If it is heated with air distribution, then the amount of investment required to use the hot water systems that go with it may be such that it is not economical. If it is heated with steam, then solar thermal is difficult because that requires a high input temperature and a bigger investment.

I don't know what the nature of the heating systems in these buildings is, so it may or may not be easy to convert them.

Mr. BOLAND. One of the reasons I ask the questions is we have the Council on Environmental Quality before this Committee, and one of the reports of the CEQ indicated that by the year 2000 solar energy may be meeting about 20 percent of all our energy needs. On another subcommittee on which I serve, I asked Secretary Schlesinger what he thought of the chances of meeting that 20 percent mark in the year 2000 and he indicated that was not a realistic expectation. What do you think?

Dr. FROSCH. I hesitate to intervene between two other experts.

Mr. BOLAND. We would like you to intervene.

Mr. COUGHLIN. Do you still have the solar experiment going on at Huntsville?

Dr. FROSCH. Yes.

Mr. COUGHLIN. What is the status of that?

Mr. BOLAND. And what kind of solar experiment is it, incidentally?

Dr. FROSCH. If it is the one I am thinking of, it is direct solar thermal, that is solar heating of hot water which is then used for heating the building.

Mr. COUGHLIN. What have the results of that been?

Dr. FROSCH. I don't know what they are off-hand. It is relatively new, and I am not sure we would have satisfactory data on that.

Mr. COUGHLIN. It is not relatively new. It has been going on for a couple of years now.

Dr. FROSCH. That is relatively new for getting a data base on a seasonally dependent thing like heating and cooling. Five years is probably a reasonable cycle for really understanding what is going on.

Mr. COUGHLIN. Have there been any changes or modifications, or is it an ongoing project?

Dr. FROSCH. I think it is ongoing. But we will have to get details for the record.

[The information follows:]

The Solar Heating and Cooling Demonstration House at Marshall Space Flight Center has been in use several years to obtain actual operating experience with solar equipment. The 1,500 square foot building receives hot water, heat and

part of its cooling requirements from about 1,200 square feet of solar collectors on the roof or adjacent to the building. In its recently renovated configuration, it has four types of solar collectors, a heat pump, a commercial absorption chiller, a hot water system, two water storage tanks and a number of heat exchangers and controls. These components are used in combinations to evaluate relative efficiencies. The Demonstration House activities are part of the solar heating and cooling development program performed by NASA for the DOE.

Mr. McGARVEY. We have a similar project at Johnson Space Center, with the Mission Control Center. Again, it is limited to providing supplemental heat for reheat or humidity control for that building. But these are purely demonstration projects for the purpose of gathering data and determining what impact they can really bring about.

Mr. COUGHLIN. If I might just stay with that for one second; what is your objective and what do you intend to demonstrate or try to demonstrate?

Dr. FROSCH. To find out the effectiveness and the economics of the system. Given that there was a certain investment, we will get enough data over a few years to find out what the rate of amortization of the investment is from the saved fuel cost. There may be some preliminary data now which I haven't seen. Do you have any, Jim?

Dr. KRAMER. Yes, although most of the data has to do with the Solar Heating and Cooling Demonstration program which the Marshall Space Flight Center has been overseeing for DOE. This includes the installation and operation of many systems. The first stage of that program involved solving many engineering problems to keep these systems operational, no matter what the cost. We are fairly well through that phase, and now we are to the point where we are collecting data which give us some feeling for the economics. The bottom line, at this stage, is that solar heating is beginning to approach cost competitiveness, but still it is not cost competitive with heating with fuel oil. Solar cooling is far from being cost competitive. Providing air conditioning for a home is a much more difficult technical and economic problem. I think the message here is that the Marshall Space Flight Center will be a better judge because of its overall experience in the solar heating and cooling field.

Mr. COUGHLIN. Thank you, Mr. Chairman.

NATIONAL TRANSONIC WIND TUNNEL FACILITY

Mr. BOLAND. On CF 9–2, a $12 million request is itemized for the final construction phase of the National Transonic Wind Tunnel Facility at the Langley Research Center. It would appear from the justifications that this facility is still on schedule and that it is coming within the $85 million cost estimate that General Curtain felt very comfortable with last year.

That is correct, isn't it? Are you comfortable with the estimate this year too?

Mr. McGARVEY. Yes, sir, I am fairly comfortable. It is a very tight $85 million cost limitation, but we are on schedule. We have a couple of major items, you could term risks, that are yet to be done which can affect the cost.

Our analysis at this point is that we will be able to bring it in within the $85 million.

AMES RESEARCH CENTER SUBSONIC WIND TUNNEL

Mr. BOLAND. The balance of the Large Aeronautical Facilities request, is detailed on page CF 9–22, where you are requesting $33,900,000 for the continued modification of the 40-by-80 foot subsonic wind tunnel at the Ames Research Center. This, I understand, is the last increment of the project.

Is it correct to assume that the total cost is still pegged at $85 million? You have previously indicated that.

Mr. MCGARVEY. That is correct.

Mr. BOLAND. On CF 9–26, in the third paragraph, the justifications describe a number of significant risks. For example, it idicates that, "Additional risks associated with the installation of the drive system and the fabrication of the flow straighteners clearly show that this project faces major technical and managerial challenges."

What is the current status of this project?

Mr. MCGARVEY. The current status of the project is that we experienced some major difficulties with the structural steel packages and an earlier package to modify the existing 40-by-80-foot tunnel that is required because of the repowering and the larger flows of air in the tunnel.

When we opened the bids we were about $5 million over what we expected to be a $16 or $17 million work package. This forced us to go back and reanalyze our total project management. We redesigned that work package and have put it back out on the market.

It is being reprocured. We will open those bids in the middle of April. That was the first major difficulty that we encountered. We strengthened our project management office by making some changes. We increased the size of the staff from 43 to about 89 people.

We almost tripled the engineering resources that were available to the project manager to draw on from the Center in order to solve these difficulties. At the same time we put new people in some of the key positions.

The flow straighteners and the installation of the drive system are simply two of the major items which are yet to be completed. We are well down the road in the design of those, and we will soon put those on the market.

We simply cite those items as additional challenges and as additional risks, but we are reasonably confident that we will be able to make the $85 million cost target.

REPAIR OF FACILITIES LINE ITEM

Mr. BOLAND. Turn to CF 12–1. You have a new line item included here known as repair of facilities. I don't know how this is fundamentally any different from the rehabilitation and the modification function where this activity has been conducted for many years. Is it the same thing?

Mr. MCGARVEY. Yes, sir, it is a very fine-line attempt to differentiate between rehabilitation and the repair item that we are asking for here.

In the past, in the rehabilitation and modification line, about 40 percent of these projects have been types of repair projects. The routine

day-to-day maintenance and rehabilitation activities that are normally funded from R&D and R&PM accounts include repairs under $100,000, which we have done in the past from these two accounts. As the competition has increased for those limited funds, we looked again at a more centrally managed program for major repairs in the C of F program that would be better and would lessen the competition for the R&D funds.

Obviously facility work suffers in that type of competition with R&D requirements.

Mr. BOLAND. I notice on CF 13–23, the justifications describe the rehabilitation of the headquarters building at Wallops, including the installation of new doors and windows, the installation of new lighting fixtures, flooring, ceiling, et cetera.

That description sounds a great deal like descriptions under the repair section, which essentially describe the same kind of work.

Mr. MCGARVEY. May I attempt to clarify that? The fundamental difference is that in the rehabilitation and modification program we have put the emphasis on enhancing or improving the capability of a facility. The modifications are obvious in that regard.

In the rehabilitation work, we have made a thrust to improve or enhance the facility's capability; whereas in the repair projects we are emphasizing major repairs, in order to restore a facility to its original design capability, thereby prolonging its life.

As I said earlier, it is a fine line between the two. We also are affected by the fact that even some of our newer centers, such as Goddard and Johnson, are now beyond the 15 year mark. At about 15 to 16 years you start having some major breakdowns in utility systems and requirements for replacement of roofs and major breakdowns in equipment due to cyclic maintenance that has not been taken care of and that is longer than a one year period.

This is the type of work which we are trying to provide for with the new repair line item.

Mr. BOLAND. The new line item, repair of facilities, was not conceived as a result of the $5 million reduction which was recommended last year by this Committee via the modification and rehabilitation program, was it?

Mr. MCGARVEY. No, sir. You will notice that our request this year for rehabilitation and modification is back at about the same level as prior years.

Mr. BOLAND. All right. Let me ask you a question with respect to minor construction. The staff did a little analysis of the per square foot cost of the construction of various typical buildings at the various research centers.

It is difficult to understand why there is such a variation of square foot costs, and why some of the costs are so extraordinarily high. For example, the construction of an addition to the laser research building at the Jet Propulsion Laboratory appears to run about $82.00 per square foot, while the construction of the personnel division building addition at the Langley Research Center is $48.00 per square foot.

Mr. MCGARVEY. Sir, it depends on the complexity of the buildings.

Also, there are area cost factors involved. Southern California has a much higher construction cost index than Norfolk, Virginia.

Mr. BOLAND. Do you know the large Department of Housing and Urban Development building? It was built at $22.00 per square foot. Could you do it today? What would it cost today?

Mr. MCGARVEY. No, sir. You couldn't possibly do it. It would cost today around $75.00 to $90.00 per square foot in the Washington area for office buildings of that type.

AUTOMOTIVE MAINTENANCE FACILITY AT KSC

Mr. BOLAND. Now we will turn to CF 14–10. That page indicates that you are carrying $82,000 for the construction of an automotive maintenance facility at the Kennedy Space Center. Are you familiar with OMB's A–76 requirement which suggests that much of this kind of work should be contracted out with private shops? I suppose a number of the small businesses in Cocoa Beach would welcome the business and would be pleased to provide front-end alignment and tire services.

What about this?

Mr. MCGARVEY. I don't know whether a look was taken at the option of contracting it out as opposed to continuing to do it in-house. But it has been done in prior years in-house at Kennedy. We have a motor pool to do this work for the GSA vehicle fleet assigned to KSC.

Mr. LILLY. We did look at ways several years ago, and we decided that the best way was to go to GSA for the vehicles. This was merely a matter of providing the space for GSA to work in.

Mr. BOLAND. I think you ought to look at it more closely.

Mr. Coughlin?

FUTURE SPACE SHUTTLE FACILITIES

Mr. COUGHLIN. Thank you, Mr. Chairman. Just to elaborate a point that the Chairman has made; for Fiscal Year 1980, your budget proposes $31,450,000 for construction of Space Shuttle facilities for the first orbital flight soon to be a reality. What other projects, other than completion of Launch Pad B, may the Committee expect to see in the future? Will other facilities involved in that be coming up?

Mr. MCGARVEY. Yes, sir, there may be. It isn't definite yet, but there may be a requirement for solid rocket motor storage facilities, either at KSC or at the plant where they are being manufactured. Also downstream, the only other major requirement, and that decision has not yet been reached, is whether a third mobile launch platform will be required to support the increased flight rates. If one does come into the program, then there will be a major requirement to modify that mobile launcher platform. John?

Mr. YARDLEY. I would add that probably for the original mission model additional facilities may be necessary for processing both the solid rocket boosters and the external tanks. We are looking at the solid rocket motor right now. I think we have a twenty-four flights per year capability. We are considering second source competition, with a possibility of the winning contractor providing its own facilities.

Mr. COUGHLIN. So you have a projected flight schedule now? Don't you know at this point in the game whether you will need the extra facilities or not?

Mr. YARDLEY. What I don't know is whether I can get private industry to put the facilities in or whether we will have to make that investment ourselves. In terms of the third mobile launcher, there is a question whether we will need that or not, depending on how the flow goes at the Cape. If we can turn orbiters around as fast as we think we can, we may not need it, but that will have to wait on experience.

Mr. COUGHLIN. I recall one of the Chairman's questions concerned the repair of facilities. How were these small repairs treated in the past?

Mr. MCGARVEY. Sir, in the past, we attempted to include those repair jobs within rehabilitation and modification. It was an administrative decision within the Agency, that if it was between $100,000 and $500,000, we would include it in the rehabilitation and modification line. Those under $100,000 were normally taken care of from R&D and R&PM resources. Anything over $500,000, of course, became a discrete line item.

Mr. COUGHLIN. The last line in the repair section of the justification states that the early requirements may be, "conservative and underestimated." Are you really telling the Subcommittee that this is a new and expensive program?

Mr. MCGARVEY. We are saying that, for example, this year we screened or distilled that $12 million requirement from a submission of over $25 million worth of requirements. There will be follow-on requirements at some level in the program to continue this necessary repair program.

Dr. FROSCH. I think what we are telling the Committee is that last year was the 20th birthday of NASA, and therefore it is getting to be a fairly advanced birthday for many valuable facilities. As General McGarvey says, after a facility becomes 15 years old, you begin to have major repair problems.

RESULTS OF FY 1979 BUDGET REDUCTION

Mr. COUGHLIN. On page CF 13-24, you indicate that there are $3,545,000 worth of projects that were not accomplished in Fiscal Year 1979. Why were these not completed?

Mr. MCGARVEY. Sir, we did suffer a $5 million reduction last year in our rehabilitation and modification request. We were able to fund $1.5 million of those, but this $3.5 million represents the projects that we could not accomplish because of the reduced funding.

Mr. COUGHLIN. Were these NASA's lowest priority projects?

Mr. MCGARVEY. The majority of them were in the lower third of the priority listing. There have been some adjustments in the priorities since that list was furnished to you last year.

Mr. COUGHLIN. Does each one of these rank higher than those projects listed for the first time in Fiscal Year 1980?

Mr. MCGARVEY. Many of them rank with the top items that are in our FY 1980 request. We have ranked them by categories internally as to whether it is a programmatic critical item, whether it is programmatically related, or whether it is a routine institutional item. We put them in broad categories and most of these fit in the critical upper section of that priority list.

Mr. COUGHLIN. Thank you, Mr. Chairman, I have no further questions.

Mr. BOLAND. Thank you very much, General McGarvey. What is Bob Curtin doing now?

Mr. MCGARVEY. He works in town here for a consulting engineering firm.

Mr. BOLAND. He is a very fine man. I always respected his judgment and his ability and I am sure you will enjoy working with NASA, too. So, thank you very much.

Mr. MCGARVEY. Thank you, Mr. Chairman.

TRDSS BUDGET CLARIFICATION

Mr. BOLAND. Let me return to TDRSS for a moment. Bill Schneider wants to clarify the record and give us some additional information with respect to the tracking and data system. We know about the $80 million overrun which we discussed yesterday. I understand that there may be, in addition to that, a substantial overrun because the Federal Financing Bank will have to extend the period of the loan for an extra year, from 1980 to 1981, due to the Shuttle delays. Can you tell us about the problem? How much will it cost and are there any other funding problems that will increase the cost of the program?

I understand that the Federal Financing Bank picks up this additional cost but, of course, it is true that, regardless of whether it is counted as off-budget or on-budget, it still comes out of the taxpayers pocket.

Dr. SCHNEIDER. I wouldn't categorize them as overruns. I would categorize them as cost increases.

Mr. BOLAND. I thought an overrun was a cost increase?

Dr. FROSCH. I think all overruns are cost increases, but not all cost increases are overruns.

Mr. BOLAND. It depends on which side of the table you are sitting on.

Dr. SCHNEIDER. At the time the contract was let, there was included in the cost of the contract a projection of the inflation rate. The inflation rate was projected as five percent. There also was a projection in the contract as to what the interest rate was going to be at the Federal Financing Bank; that was seven and a half percent. As you know, inflation has been considerably above that. In fact, the interest rate has been running between nine and a half and ten percent. In the contract, there is an economic adjustment clause to provide for those items. We have not yet negotiated these economic adjustments back into the contract. So, that must be done. Some of the costs have been experienced and some are yet to be experienced.

In addition, the contract payback begins on the date of assumption of service. That date of service has changed by one year. We must now go back to the Federal Financing Bank and negotiate that additional length of time as well.

So all of those costs will add up to an additional increase in contract value, approximately $130 to $140 million that have not yet been negotiated. But I wanted to make clear to the Committee that these things were still open and that they are inherent in the basic contract and are not under our control.

Mr. BOLAND. What does that do to the total cost of the Tracking and Data Relay Satellite System?

Dr. SCHNEIDER. With just those items, it brings us up to slightly over one billion dollars in cost.

Mr. BOLAND. Thank you very much and thank you for bringing that to our attention. I understand this will be the last time that Dr. Hinners will be before the Committee. It has always been enjoyable having him here. He is going, I understand, to become the Director of the Air and Space Museum.

That is really a marvelous place. You will be replacing Michael Collins there, I understand. He was, in a sense, the project manager on that building. That was probably the only Federal building in Washington that was built on time and on schedule and within cost. Now it has more visitors than any other government building in Washington. So we want to congratulate you on the service you have given to NASA as the Associate Administrator for Space Science. We have enjoyed your comments and responses on the Jupiter Orbiter Probe and the Space Telescope and other areas where we perhaps differed momentarily. So, on behalf of the Subcommittee, I want to express our appreciation to you for your forthrightness and your nice personality and wish you luck in the new position.

Dr. HINNERS. Thank you very much.

RESEARCH AND PROGRAM MANAGEMENT OVERVIEW

Mr. BOLAND. We will turn to Volume III, Research and Program Management. You are requesting $964,900,000 in 1980 for the Research and program management account. That compares with the current estimate for 1979 of $941,469,000. The $941,469,000 assumes enactment of the $30,969,000 supplemental appropriations to cover the pay cost increase of last November. On page SUM 4 you indicate that you are absorbing $4,111,000 of the total pay cost increase for 1979. Specifically, from what areas are you absorbing the $4,111,000? Is it all from the savings accrued because total permanent employment drops 406 positions in 1979?

Mr. KLINE. That is correct, sir. We are coming down by 406 positions in total in FY 1979 and another 268 positions in FY 1980. The distribution of the reduction by center is shown on page SUM 11 and, by program, on page SUM 12.

Mr. BOLAND. You indicated that, in addition to the 406 position reduction in 1979, you were absorbing a further decrease of 268 positions in the 1980 budget for a total of 674 positions. Can the Agency afford that kind of position reduction?

Dr. FROSCH. It is making it extremely difficult for NASA to keep its professional skills in balance and to recruit people. An R & D agency has to have some flow through of people, and has to bring in some recently educated people, and it is extremely difficult for us to do that with these constraints. It is putting a real squeeze on keeping the competence of the Agency up through the years.

Mr. BOLAND. What action did OMB take out in this area? Did NASA ask for more or less positions in their request to OMB?

Dr. FROSCH. We essentially asked for a level number of positions; no change. There was an OMB recommendation of a cut larger than

what was finally allocated to us. We strongly appealed for restoration of part of that cut on the basis that it would affect the management of the Space Transportation System on the Shuttle. The cut was reduced essentially by the amount that we appealed, for that reason.

PERSONNEL REDUCTIONS AT MARSHALL AND LEWIS CENTERS

Mr. BOLAND. I note on page SUM 11, the distribution of the permanent positions by installation. The Marshall Space Flight Center reduction is 75. Some of the others are not a very large reduction, but next to the Marshall Space Flight Center, one of the largest reductions occurs at the Lewis Research Center with 23 positions lost.

Why are these two particular installations more heavily impacted by personnel reductions?

Mr. KLINE. Mr. Chairman, the analysis we did to determine where we should take the reductions had to take into account a number of factors, including current phasing of our programs, and the priorities of the Agency. We have to take cuts where the least amount of damage may be done and base it on the general assessment of all of the programs to arrive at these kinds of decisions. The numbers reflect the allocation among the centers on that kind of a basis.

Mr. BOLAND. What type of positions would be eliminated at Marshall, for instance?

Mr. KLINE. At the Marshall Space Flight Center, the majority of those positions are going to be engineering and technical support positions. A lesser number will be administrative.

Mr. BOLAND. What is the current on-board employment of NASA?

Mr. LILLY. It is 22,936 at the end of February.

Mr. BOLAND. Concerning the 406 permanent position reductions, what lapse rate did you project for 1979? Was it six months, five months, four months?

Mr. KLINE. We are anticipating that the phasing of the reduction will be during the last half of the fiscal year. We received the final numbers at the end of calendar year 1978. The centers are now in the process of formulating their plans for taking these reductions. We expect that most of the reductions will be done by attrition at just about all the centers. There could be some selected reductions in force which would take place toward the end of the fiscal year.

Mr. BOLAND. So what would the lapse rate be? Six months?

Mr. KLINE. It would be a little over six months.

NASA TRAVEL BUDGET

Mr. BOLAND. On page SUM 7, the justifications outline the three areas of travel: program travel, scientific-technical meeting travel, and management and operations travel. For 1979 and 1980, what is the breakdown by these three categories of the 1979 estimate of $18,573,000 for travel and the 1980 estimate of $19,797,000 for travel? You can supply that for the record.

Mr. KLINE. We will do that. In FY 1980 the majority, over 73 percent, is in program travel; and of the other 27 percent, 7 percent is in scientific-technical travel, and 20 percent is in management and operations. We will supply the precise numbers for the record.

[The information follows:]

	Fiscal year 1979	Fiscal year 1980
Program travel	$13,525,000	$14,380,000
Scientific and technical meeting travel	1,204,000	1,344,000
Management operations travel	3,844,000	4,073,000
Total	18,573,000	19,797,000

Mr. BOLAND. I presume that the scientific and technical meetings and the management operations travel, are both classified as administrative travel?

Mr. KLINE. Our administrative travel is classified exclusively within the management and operations travel category.

Mr. BOLAND. How about the OMB directive reducing administrative travel by 20 percent in 1979? Has NASA complied with that directive?

Mr. KLINE. Yes, sir. We have reduced $164,000 from administrative travel on the basis of that directive. That was 20 percent of the administrative travel in NASA.

Mr. LILLY. That, incidentally, Mr. Chairman, was part of the offset you asked for. That was also part of the absorption.

Mr. BOLAND. Last year NASA justified its travel about $1.7 million above the 1978 travel budget on the basis that the Shuttle would be making its first flight and therefore substantial increases in program travel were requested. The Shuttle won't make its first flight in FY 1979. However, I noticed that travel still increased by about $1.5 million over 1978. Why?

Mr. KLINE. We are in the heart of the development and test program with the activities going on between the Kennedy and the Johnson Space Centers and involving the various contracting locations. There is also the intensive activity at Michoud on the external tank and at NSTL, with the problems on the main engine.

Mr. BOLAND. Would those be the same reasons for the projected increase of $1.2 million for 1980?

Mr. KLINE. Yes, sir. A very large part of that is for the critical phase of the program.

MANAGEMENT AND OPERATIONS SUPPORT

Mr. BOLAND. On SUM 3, I notice that the estimate for Management and Operations Support in 1979 is substantially higher, by about $5 million, than the original 1979 budget estimate. Why is that? I notice that the Management and Operations Support budget estimate was $56,968,000 and the current estimate is $61,492,000, which is about $5 million over the budget estimate. Why is that?

Mr. KLINE. There are two primary reasons, Mr. Chairman. The first is a rephasing at the Kennedy Space Center to prepare for the Shuttle period for base operation types of support. In that regard, they phased the other way at Kennedy in facility activities to bring elements up to speed. In terms of base operations support at Kennedy, that has already begun in 1979. We have added about 69 man years; half of that is down at Kennedy in support of the buildup.

The other requirement is the programmed acquisition of the Gulfstream II and that item is carried in the Management and Operations Support line at $2.4 million.

Mr. BOLAND. Where did that money come from?

Mr. KLINE. To find the funding for the Gulfstream II, we did some scrubbing across the Agency. One source was the rephasing of some of the work from facilities operations at KSC into FY 1980 because of the delay in Shuttle launch. A second was the rephasing of the funding of some of our support contracts. We generally fund those for periods that cross fiscal years, 12-month periods, and in certain cases we can reduce those periods to less than 12 months and make the adjustment in FY 1980. With that combination, we were able to plan the funds for the Gulfstream II.

Mr. BOLAND. On that same page in that table, I notice that personnel costs in 1979 increase from $695,093,000 to $720,924,000 in the 1979 current estimate.

Mr. KLINE. Yes, sir.

Mr. BOLAND. However, the cost of the pay increase is estimated to be $35 million. That is correct, isn't it?

Mr. KLINE. That is correct, sir.

Mr. BOLAND. Why isn't the full $35 million increment above the budget estimate reflected on this line for personnel and related costs?

Mr. KLINE. The salary increase was correctly priced at $35 million. However, we have been able to absorb over $4 million with the savings from the 406 position manpower reduction and the OMB directed cut in administrative travel. The supplemental request of $31 million is the net cost of the salary increases in 1979.

The remaining $5 million difference between the 1979 budget estimate for Personnel and Related Costs and the current 1979 estimate is due principally to personnel planning adjustments made prior to the beginning of 1979 in anticipation of the manpower reduction and to accommodate the $3.5 million Congressional reduction to NASA's 1979 request.

SPACE FLIGHT OPERATIONS PERSONNEL

Mr. BOLAND. On SUM 12, you indicate that the number of permanent positions assigned to Space Flight Operations had been scheduled in 1979 to increase by about 1,000 over 1978. The 1978 figure was 1,081 and the budget estimate for 1979 was 2,082. Your 1979 budget estimate nearly doubled the 1978 level. As it has turned out, the increase is only about 300 positions. Isn't that correct?

Mr. KLINE. That is correct, sir.

Mr. BOLAND. Is that because the Shuttle isn't going to fly in 1979?

Mr. KLINE. That is exactly right, sir, it is the rephasing of the operational activities. And you will notice the reduction in positions for the Space Shuttle did not come down as much as we had initially expected because of that delay.

Mr. BOLAND. In 1980, you are suggesting that it will increase an additional 400 positions, from 1,300 to 1,791?

Mr. KLINE. That is the current plan, sir.

Mr. BOLAND. So that is still about 300 short of your original 1979 estimate. That brings us to this question: Why can you do in 1980 essentially what you would have had to have done in 1979 if you had flown in 1979 with 300 positions less than what you thought you would need in 1979?

Mr. KLINE. I wish I understood that question.

Mr. BOLAND. The permanent positions estimate for 1979 was 2,082 and now the 1980 estimate is 1,791, so you have 300 less positions now. What could you have done in 1979 if you had flown in 1979 with 300 positions less than what you thought you would need in 1979?

Mr. KLINE. This change, Mr. Chairman, includes a revision of the accounting of manpower that had initially been allocated to space flight operations in our 1979 plan. We have done some work across the Agency in terms of user charges for the Space Shuttle and this has resulted in a reallocation of some of that manpower to user accounts on other program lines. That is also factored in there.

WITHIN-GRADE SALARY INCREASES

Mr. BOLAND. Last year, on page 131 of the hearings, NASA submitted for the record information which suggested that the number of within-grade increases denied by NASA in Fiscal Year 1976 was 19 and in Fiscal Year 1977 was only 28. You further estimated that the total cost of within-grade advances in Fiscal Year 1979 was about $6.5 million additional.

Now, denying 28 within-grade increases considering a total employment of 24,000 or 23,000 is really not very many. Would it be unfair to specifically reduce the funding for within-grade pay increases by ten percent and direct you to take a ten percent reduction? Would that be unfair?

Dr. FROSCH. I think it would be unfair relative to the overall practices in the government.

Mr. BOLAND. If we had done it with every agency, it wouldn't be unfair.

Dr. FROSCH. If you had done it with every agency, it would then be a direction of what percentage of within-grades we should allow. I don't really know what would happen relative to Civil Service regulations if that were the case.

Mr. KLINE. Mr. Chairman, that is correct. The Civil Service Reform Act is being implemented and all supervisory and managerial people are being removed from provisions for within-grade promotions. There is going to be a restructuring of within-grades in the context of merit pay.

NASA CONTRACT DISPUTE

Mr. BOLAND. We won't tamper with it. I think that is a good explanation. Last year on page 134 of the hearings, we discussed NASA's contract award to Computer Sciences Corporation that was protested to the GAO by a company that is known as Informatics. Dr. Frosch indicated that it appeared that the GAO investigations were correct in that CSC had made a significant misstatement to the selection authorities on certain information that was vital to the contract award. You indicated at the time of our hearings that if this misstatement had truly been made, then you would redirect this selection and have it go in favor of Informatics. What finally happened to that case?

Mr. HOSENBALL. There was a GAO decision on that.

Mr. BOLAND. What was that decision?

Mr. HOSENBALL. I am trying to recall now. I would like to check on it.

Mr. BOLAND. What is the status of it now? Who received the contract?

Mr. HOSENBALL. Whatever the decision was, we followed it.

Mr. BOLAND. Has the contract been redirected?

Dr. FROSCH. I don't think any of us remember, Mr. Chairman.

Mr. HOSENBALL. I will have to get that information. I really don't remember.

Mr. BOLAND. Okay. It might be advisable to read the last year's hearings in this area.

Mr. HOSENBALL. I recall the case and I do know a decision was issued. I do know we complied with whatever GAO said we should do.

WORK YEARS AT DRYDEN RESEARCH CENTER

Mr. BOLAND. Let me go back to last year's hearings on page 147 where there was an exchange with Ray Kline over the question of 63 work years that were split between 25 assigned to janitorial and 38 for security at the Dryden Research Center. Page 910 of the hearings volume from last year details the 1979 justifications. On page RPM 8–13, this year's justifications discuss a total of 43 work years of effort. As the hearing record describes on page 147, the justifications suggested last year that you were paying $523,000 to support 63 people in 1976. But in 1979, you asked for $1,406,000 to support the same 63 people.

It appears now that you are only supporting a total of 43 work years in 1979, at the current estimate of $962,000. What about that?

Mr. KLINE. That entire line is not in support of work years of effort. A portion of that goes into the supplies and equipment that are also involved in rendering services. I have not brought along to the hearing the cost per man year. I can check the records and will be glad to supply that for the record.

Mr. BOLAND. We asked for a breakdown last year and we never got the breakdown. On page 147 of last year's hearings you said, "This number 63 refers to the 1979 level of 25 work years for janitorial and 38 work years for security."

I responded, "Why not try to break that out because if you look at the figures—certainly the legend indicates that this is so—you are paying $523,000 in 1977 for 63 people. Now, that increases to $1,406,000 for 63 people in 1979. We would be paying janitors, laundry workers, custodial service something like $25,000 each. You don't do that, do you?" You said, "No."

Dr. Frosch then added, "Mr. Chairman, we should note, pending the detailed numbers, that the last sentence of paragraph C notes that the guard services are to be increased to support the OFT program."

What program is that?

Dr. FROSCH. That is the orbital flight testing program.

Mr. BOLAND. Continuing on I said, "Yes, but how much?"

To this you responded, "We will have to provide the precise numbers."

But you never did break out the increase to $1,406,000 for the 63 people in 1979. Will you do that for the record?

Mr. KLINE. Yes, sir. We will have that within a week.

[The information follows:]

DFRC CUSTODIAL SERVICES
(Dollars in Thousands)

	1979 Budget		1980 Budget	
	1977 Actual	1979 Budget	1979 Current	1980 Estimate
Purchased Goods & Services	1	4	13	9
Support Service Contracts	522	1,402	949	1,006
TOTAL	523	1,406	962	1,015
Support Service Contracts Only				
Janitorial Obligations	465	634	448	493
Prior Year Funding	185	-	-	-
TOTAL COST	650	634	448	493
Work-Years	29	25	18	19
$ per Work-Year	22,414	25,360	24,889	25,947
Security Obligations	57	768	501	513
Prior Year Funding	538	-	-	-
TOTAL COST	595	768	501	513
Work-Years	36	38	24	24
$ per Work-Year	$16,528	$20,211	$20,875	$21,375

The changes in work-year levels from year-to-year and budget-to-budget reflect the fluctuating nature of the Shuttle support activities. The levels were high in 1977 to support the ALT effort and in the 1979 Budget to support the OFT activity. The current estimates for 1979 & 1980 reflect the delays and uncertainties inherent in the current Shuttle planning.

The changes in the cost per work-year are due primarily to: (1) the fluctuating work-year levels as the skill mix changes periodically to accommodate program requirements and (2) negotiated support contract wage increases. The apparently high wage levels at DFRC on the janitorial contract havebeen a concern to NASA for some time. As such, we have requested a Labor Department investigation, which is currently in progress. We will apprise the Congress of the results when completed.

FACILITIES SERVICES AT JOHNSON SPACE CENTER

Mr. BOLAND. On page RPM 1–17, under Facilities Services for the Johnson Space Center, I note that the current estimate for that activity is about $2.5 million less than the budget estimate last year. In the paragraph at the bottom of the page it is indicated that the reduction is caused by a rephasing of support contract funding to align it with the year in which the work is performed. What does that mean?

Mr. KLINE. Each of the R&PM-funded contracts is generally phased for a 12 month period which does not coincide date-wise with the fiscal year. In this case, at Johnson, we adjusted the FY 1979 funding plan downward so that the contract would not extend as far into FY 1980 as we had originally planned. This was one of the ways which we have found to make funds available for the acquisition of the Gulfstream II.

Mr. BOLAND. The requested increase in 1979 of $17,560,000, above the 1978 level of $15,876,000, is explained in last year's justifications as due to the full year effect of the 1978 negotiated contract on wage rates which had to provide for 12 months funding in 1979. Last year's justification for the increase and this year's justifications for why the increase never occurred don't seem to match up.

Mr. KLINE. And the reason is, sir, because of the rephasing of the contract to cover a shorter period of time than we had planned for last year at the time we presented the FY 1979 budget.

Mr. BOLAND. On RPM 1–20, under Utilities Services, I note that you are doing quite well in 1979 and that your current estimate of $17,148,000 for Utility Services is about $1,100,000 less than the budget request. Is that one place where you are going to be saving some of the $2.4 million that we talked about in the rescission?

Mr. KLINE. No, sir. The utilities reduction results from a consumption decrease, which was expected and commodity rate increases that we had anticipated in utilities that didn't occur, at least to the extent that we expected them to. The fact that this happened, did make funding available for the acquisition of the Gulfstream which will be applied in the rescission.

Mr. BOLAND. Last year there was a reduction of $3,500,000 in Research and Program Management. Isn't that correct? Where did you apply the $3,500,000 reduction approved by the Congress in the 1979 Act for this account?

Mr. KLINE. The absorption of the reduction of $3.5 million was the result of the kinds of factors I stated earlier. One, across the whole appropriation, the rephasing of base support for the Shuttle because of the delay in the Shuttle moving into the operations phase; second, a reduction in hiring because of the anticipated cut in ceiling; and, third, a rephasing of the support contract or funding to cover a lesser period. By taking those in total, we found the $3.5 million.

KENNEDY SPACE CENTER JANITORIAL AND SECURITY SERVICES

Mr. BOLAND. On RPM 2–16, under the Kennedy Space Center, we are looking again at the question of janitorial and security services. On that page, I note that it is costing $5,341,000 in 1980 for 205 work-

years, and that works out to about $26,000 per work year. How much of the $5,341,000 is actually devoted to salaries and related benefits?

Mr. KLINE. I don't have that information here, Mr. Chairman. I will be happy to supply that for the record.

[The information follows:]

At KSC, the security services support service contractor is the Wackenhut Services, Inc. In FY 1980, the total cost of the 205 work-years of effort is $5,341,000 or $26,054 per work-year. The cost of this contract is almost totally labor driven, with minimal funds included for supplies and materials. The contract with the Wackenhut Services, Inc. is a fully loaded contract, which means the costs of overhead, G&A, fringe benefits, other payroll additives and fee are added in the factors ranging from 25 percent to 50 percent. As you know, the Services Contract Act of 1965, as amended, applies to support services contracts, including KSC's contract for security services. Thus, it is the Department of Labor, not KSC or NASA, which prescribes wages paid and fringe benefits provided to service employees. While we do not always agree as to the realism or appropriateness of DoL's determinations, we are required by the Act to incorporate them into our support services contracts and to assure compliance by contractors. In summary, insofar as the basic question of security costs is concerned, we consider ourselves to be in strict compliance with the letter and intent of OMB Draft Circular A-76, the Service Contract Act, and DoL's regulations implementing it.

JOHNSON SPACE CENTER CUSTODIAL SERVICES

Mr. BOLAND. All right. Now on RPM 1-19, under the Johnson Space Center, custodial services involving 234 work years at a total cost of $3,086,000 in 1980 only averages $13,188 per work year. How are these same services provided for at half the cost at Johnson as compared to Kennedy?

Mr. KLINE. I would also like to supply that for the record.

Mr. BOLAND. You may.

[The information follows:]

Some of the particular circumstances concerning KSC have already been discussed. With regard to JSC, the total cost of Custodial Services in FY 1980 is $3,086,000, of which $13,000 is for supplies and services. The remaining $3,073,000 provides for 234 man-years of effort on three contracts, averaging $13,132 per man-year. They are:

1. Janitorial Services at $11,901 per work-year;
2. Security Services at $17,150 per work-year;
3. Fire Protection Services at $27,130 per work-year.

The difference in cost per work-year paid for security services at JSC and KSC is that they are based on the different rates prevailing in the geographic areas as determined by the Department of Labor.

Dr. FROSCH. But I think we understand the basic reason for the differential. This is under the Service Contract Act and the labor rates are determined in accordance with the Department of Labor (DOL) survey. At Kennedy, the area surveyed for labor rates for determination is Kennedy itself. DOL does not include in its survey the rest of Brevard County outside the government enclave. The rule is that when the service contract is renegotiated, the new salaries may not be lower than the old salaries in the surveyed area.

In effect, at Kennedy we are on a rising cycle under the rules of the Service Contract Act and the current groundrules applied to the wage surveys. We have suggested to the Department of Labor that the appropriate area to be surveyed for comparability would include part of the area outside the gates.

Mr. BOLAND. Does that just apply to the Kennedy Space Flight Center?

Have they done this at Johnson?

Dr. FROSCH. At Johnson, I think they have a larger area than that enclave. I think they have the whole area.

Mr. BOLAND. Have you had many requests for transfers from janitors from Johnson to Kennedy?

[Laughter.]

Dr. FROSCH. That tends to be a local labor market, Mr. Chairman.

MAINTENANCE AND RELATED SERVICES AT MARSHALL SPACE FLIGHT CENTER

Mr. BOLAND. On RPM 3–19, under the Marshall Space Flight Center, I notice that the original budget estimate for 1979 for facilities under maintenance and related services was $1,290,000. That was a drop of $694,000 from the actual level in 1978. Why do you project such a substantial drop-off for Marshall?

Mr. KLINE. The estimate came in exactly as we have shown here and as you have stated. During the year this turned out to be far in excess of what the Center could afford to take. During the year, we examined their maintenance problems and found that the cut was too severe; for that reason we restored close to $700,000, as the current estimate shows, for the maintenance work down at the Marshall Space Flight Center. This applies not only to the major facilities, but to some of their special equipment as well.

Mr. BOLAND. On RPM 3–21, why do the 39 work years of effort under security and fire protection cost an average of $37,153 per work year? That compares with about $20,000 per work year at Goddard.

Mr. KLINE. Once again, the work years should not be directly equated with dollars. There are supplies and materials there and, if the Chairman would like, we will again break that out and supply that for the record.

Mr. COUGHLIN. It seems that some sort of breakdown could be provided so that someone looking at this could make some sort of rational judgment as to what it was costing.

Dr. FROSCH. We will be happy to do it.

[The information follows:]

The total FY 1980 cost of $1,449,000 for security and fire protection you have referred to at MSFC is made up of three distinct parts. They are:

1. Security services support contract for $941,000 (or $24,128 per work-year);
2. Fire protection provided by the Redstone Arsenal on a reimbursable basis for $438,000.
3. Purchased goods and services for $70,000.

At GSFC in FY 1980, the total cost of security services is $812,000. This figure is made up of two distinct parts. They are:

1. Security support service contract for $676,000 (or $17,333 per work-year);
2. Purchased goods and services for $136,000.

The difference in security service contract wage rates between MSFC and GSFC is due to the Department of Labor policy of pegging the rates to those prevailing in each geographic area.

CUSTODIAL SERVICES AT LANGLEY RESEARCH CENTER

Mr. BOLAND. On RP9–18, I notice that 107 work years are assigned to custodial service at the Langley Research Center which would run about $18,500 per work year. It is not as high as the average at Dryden, but it still exceeds the Johnson average by about $5,000. Why don't you supply the cost breakdown for that in the record?

[The information follows:]

At LaRC in FY 1980, the Custodial Service line totals $1,980,000. This is made up of three distinct components. They are:

1. Janitorial support services contractor for $1,105,000 (or $18,416 per work-year);
2. Security support service contractor for $810,000 (or $17,234 per work-year);
3. Purchased goods and services for $65,000.

In both the janitorial contract and the security contract, minor supplies and materials are included in the total price of the contract. The major reason for wage rate differences between Centers is the DoL policy of pegging the rates to those prevailing in the local area for similar jobs.

LEWIS RESEARCH CENTER MEDICAL PROGRAM AND RELATED SERVICES

Mr. BOLAND. What is the medical program you are talking about on page RPM 10–20, at the Lewis Research Center?

Mr. KLINE. We have an agency-wide requirement for provision of medical services at all of the centers. It turns out that the Lewis Center was the last one to come onboard, so it is a program that they began to put in place in FY 1979.

The program includes medical screening, which applies to all of our employees, regardless of age or the jobs they hold. An examination every third year is available to all the employees. This includes private physician referral, and all additional testing for people who are in specialized or hazardous work. This brings to Lewis a program which would be equivalent to that offered Ames.

Mr. BOLAND. With respect to the janitorial and fire and security services, would it be more cost effective to have those work details contracted out?

Mr. KLINE. It would vary, depending upon the location. As Dr. Frosch said, there will be some variation in rates, partly caused by the impact of the Services Contract Act. There was a time when a straightforward answer could be made that it was cheaper to contract it out. I just don't know if that is the case anymore. As we go forward, we will be doing some evaluation under the revised OMB Circular A–76 to determine which is the more cost effective.

Dr. LOVELACE. It is true, I believe, that most of the janitorial services are contracted.

Mr. KLINE. That is correct.

Mr. BOLAND. On page SUM 3, the justifications display the five major functional areas for all of NASA. For the record, I would like to have those broken down for all NASA facilities showing the same detail for each of the centers. Please supply that for the record.

[The information follows:]

	ARC	DFRC	GSFC	HDQS	JSC	KSC	LARC	LERC	MSFC	NSTL	WFC	Total
SUMMARY CONTROL SHEET												
Total personnel and related:												
1978 actual	48,214	13,777	102,718	52,528	110,801	64,543	84,607	71,998	115,638	2,648	9,978	677,450
1979 budget	49,377	13,798	104,343	54,317	113,183,	66,705	85,568	80,253	114,413	2,823	10,313	695,093
1979 current	52,584	14,396	108,433	55,981	117,880	70,123	89,266	78,334	120,323	3,083	10,521	720,924
1980 budget	53,514	14,270	110,150	56,279	118,265	70,502	89,811	80,524	119,961	3,151	10,749	727,176
Total travel:												
1978 actual	1,101	306	2,308	2,385	3,240	2,120	1,854	1,002	2,326	84	316	17,042
1979 budget	1,230	388	2,476	2,545	3,626	2,338	2,156	1,187	2,382	65	348	18,741
1979 current	1,218	369	2,481	2,494	3,505	2,416	2,008	1,126	2,492	92	372	18,573
1980 budget	1,313	415	2,672	2,697	3,781	2,368	2,154	1,208	2,684	99	406	19,797
Total operations:												
1978 actual	8,415	4,164	18,827	26,212	32,613	47,102	15,558	11,916	25,481	----------	4,726	195,014
1979 budget	8,605	5,295	17,320	27,670	33,487	49,388	16,855	12,340	24,062	600	4,544	200,166
1979 current	9,959	4,792	17,316	27,784	32,636	48,368	16,651	13,053	25,461	1,352	4,600	201,972
1980 budget	11,012	5,106	18,375	28,907	34,163	55,279	18,164	14,068	26,239	1,439	5,175	217,927
NASA total:												
1978 actual	57,730	18,247	123,853	81,125	146,654	113,765	102,019	84,916	143,445	2,732	15,020	889,506
1979 budget	59,212	19,481	124,139	84,532	150,296	118,431	104,579	93,780	140,857	3,488	15,205	914,000
1979 current	63,761	19,557	128,230	86,259	154,021	120,907	107,925	92,513	148,276	4,527	15,493	941,469
1980 budget	65,839	19,791	131,197	87,883	156,209	128,149	110,129	95,800	148,884	4,689	16,330	964,900
FUNCTIONAL SUMMARIES: PERSONNEL AND RELATED COSTS												
Compensation and Benefits												
Compensation:												
Permanent position:												
1978 actual	42,515	11,825	92,141	45,916	97,447	57,605	75,202	63,640	102,608	2,327	8,698	599,924
1979 budget	43,291	11,760	93,060	46,930	99,050	58,836	75,573	70,880	101,254	2,484	8,964	612,082
1979 current	46,306	12,293	97,064	48,135	103,124	61,765	78,864	69,172	106,254	2,680	9,096	634,753
1980 budget	47,175	12,200	98,441	48,236	103,366	62,396	79,276	71,057	105,945	2,768	9,299	640,159
Nonpermanent:												
1978 actual	583	426	656	906	1,086	638	987	800	880	49	173	7,184
1979 budget	748	352	850	1,175	1,134	841	1,126	700	1,150	62	208	8,346
1979 current	858	403	831	1,205	1,568	1,045	1,264	855	1,387	101	251	9,768
1980 budget	800	382	776	1,203	1,598	986	1,211	909	1,388	79	251	9,583

Reimbursable det.:												
1978 actual	83	32		249	1,334	157	4		125			1,984
1979 budget	313	101		279	1,905	179	34		144			2,955
1979 current	132	99		310	1,885	153			137			2,716
1980 budget	168	106		314	1,993	26			69			2,676
O/T and other compensation:												
1978 actual	422	148	266	255	406	243	342	890	787	5	160	4,284
1979 budget	427	247	751	277	624	442	510	1,046	792	7	157	5,280
1979 current	436	204	738	342	589	397	536	1,008	785	8	173	5,216
1980 budget	436	184	741	343	590	375	544	1,062	786	8	173	5,242
Subtotal, compensation:												
1978 actual	43,603	12,431	93,423	47,326	100,273	58,643	75,535	65,330	104,400	2,381	9,031	613,376
1979 budget	44,779	12,460	94,661	48,661	102,713	60,298	77,243	72,626	103,340	2,553	9,329	628,663
1979 current	47,732	12,999	98,633	49,992	107,166	63,360	80,664	71,035	108,563	2,789	9,520	652,453
1980 budget	48,579	12,872	99,958	50,096	107,547	63,783	81,031	73,028	108,188	2,855	9,723	657,660
Benefits:												
1978 actual	4,241	1,227	8,576	4,422	9,960	5,699	7,572	6,373	10,876	242	900	60,088
1979 budget	4,370	1,194	8,904	4,553	9,955	5,874	7,693	7,201	10,702	254	943	61,643
1979 current	4,557	1,253	8,960	4,658	10,306	6,230	8,041	6,933	11,221	271	956	63,386
1980 budget	4,655	1,248	9,290	4,691	10,365	6,186	8,214	7,078	11,205	278	981	64,191
Subtotal, compensation and benefits:												
1978 actual	47,844	13,658	101,999	51,748	110,233	64,342	84,107	71,703	115,276	2,623	9,931	673,469
1979 budget	49,149	13,654	103,565	53,214	112,668	66,172	84,936	79,827	114,042	2,807	10,272	690,306
1979 current	52,289	14,252	107,593	54,650	117,472	69,590	88,705	77,968	119,784	3,060	10,476	715,834
1980 budget	53,234	14,120	109,248	54,787	117,912	69,969	89,245	80,106	119,393	3,133	10,704	721,856
FICA:												
1978 actual	18	14	20	47	30	13	19	25	18	1	3	208
1979 budget	16	7	23	69	17	24	28	20	39	1	5	249
1979 current	18	7	22	68	36	26	30	30	51	1	3	292
1980 budget	18	7	25	68	36	26	29	30	51	1	3	294
Incentive awards:												
1978 actual	35	21	125	97	163	60	48	68	81	5	4	707
1979 budget	29	25	126	90	115	95	53	60	84	5	2	684
1979 current	25	27	125	145	165	95	53	75	84	5	4	803
1980 budget	25	27	125	145	165	53	53	80	84	5	4	766
Other benefits:												
1978 actual			6					4			1	11
1979 budget			9		1			4			3	17
1979 current			8		1			5			1	15
1980 budget			13		1			6			1	21
Severance pay:												
1978 actual		3	118	21	102	11	53	19	10			337
1979 budget				33					44			77
1979 current			15	35			32	32				114
1980 budget				35								35

	ARC	DFRC	GSFC	HDQS	JSC	KSC	LARC	LERC	MSFC	NSTL	WFC	Total
Supporting costs												
Transportation of personnel:												
1978 actual	157	30	165	163	161	99	39	35	218	10	11	1,088
1979 budget	33	58	145	220	150	258	95	66	196	11	6	1,238
1979 current	100	58	192	220	110	258	95	56	217	15	10	1,331
1980 budget	85	58	208	234	145	258	105	58	246	10	10	1,417
Personnel training:												
1978 actual	213	89	554	539	407	102	461	260	144	15	36	2,820
1979 budget	195	86	633	745	365	275	537	360	175	5	35	3,411
1979 current	195	86	648	760	440	275	537	310	322	8	35	3,616
1980 budget	195	92	694	732	465	275	590	360	322	8	35	3,768
Civil service services:												
1978 actual				78								78
1979 budget				138								138
1979 current				138								138
1980 budget				140								140
Subtotal, support cost:												
1978 actual	370	119	719	780	568	201	500	295	362	25	47	3,986
1979 budget	228	144	778	1,103	515	533	632	426	371	16	41	4,787
1979 current	295	144	840	1,118	550	533	632	366	539	23	45	5,085
1980 budget	280	150	902	1,106	610	533	695	418	568	18	45	5,325
Civil service retirement:												
1978 actual	2,990	854	6,450	3,217	6,835	4,050	5,285	4,381	7,211	175	616	42,064
1979 budget	3,112	828	6,514	3,291	7,018	4,177	5,305	4,986	7,076	183	636	43,126
1979 current	3,231	886	6,794	3,378	7,297	4,427	5,563	4,842	7,418	196	655	44,687
1980 budget	3,291	869	6,990	3,365	7,288	4,425	5,680	4,974	7,361	201	669	45,113
Life insurance:												
1978 actual	172	50	313	197	401	250	328	250	450	11	40	2,462
1979 budget	187	53	391	215	408	266	340	305	445	14	43	2,667
1979 current	183	42	342	212	410	274	345	246	476	12	43	2,585
1980 budget	190	42	388	217	410	274	349	251	476	13	44	2,654
Health insurance:												
1978 actual	821	254	1,452	718	1,862	1,123	1,564	1,400	2,066	50	223	11,533
1979 budget	821	250	1,749	726	1,824	1,120	1,678	1,586	1,901	51	241	11,947
1979 current	884	260	1,562	730	1,825	1,211	1,729	1,463	2,133	57	237	12,091
1980 budget	915	270	1,657	733	1,892	1,211	1,803	1,489	2,158	58	247	12,433
Workmen's compensation:												
1978 actual	205	31	92	125	567	192	275	226	1,040		13	2,766
1979 budget	205	31	92	129	572	192	289	240	1,113		13	2,876
1979 current	216	31	92	90	572	197	289	240	1,059		13	2,799
1980 budget	216	33	92	128	573	197	300	248	1,075		13	2,875

FUNCTIONAL SUMMARY: TRAVEL

Program travel:												
1978 actual	796	190	1,950	906	2,764	1,260	1,315	814	2,172	53	148,	12,368
1979 budget	865	240	2,095	1,095	3,072	1,274	1,435	992	2,157	33	164	13,422
1979 current	858	246	2,119	1,095	3,054	1,308	1,375	931	2,288	55	196	13,525
1980 budget	927	280	2,285	1,201	3,265	1,209	1,478	1,004	2,463	58	210	14,380
Scientific and tecnhological development:												
1978 actual	111	25	231	266	120	16	247	114	24	8	44	1,206
1979 budget	135	31	232	235	175	24	250	119	30	----------	46	1,277
1979 current	135	28	231	235	101	12	250	125	26	14	47	1,204
1980 budget	145	31	247	305	115	12	265	130	28	15	51	1,344
Management and operations support:												
1978 actual	194	91	127	1,213	356	844	292	74	130	23	124	3,468
1979 budget	230	117	149	1,215	379	1,040	471	76	195	32	138	4,042
1979 current	225	95	131	1,164	350	1,096	383	70	178	23	129	3,844
1980 budget	241	104	140	1,191	401	1,147	411	74	193	26	145	4,073
Total travel:												
1978 actual	1,101	306	2,308	2,385	3,240	2,120	1,854	1,002	2,326	84	316	17,042
1979 budget	1,230	388	2,476	2,545	3,626	2,338	2,156	1,187	2,382	65	348	18,741
1979 current	1,218	369	2,481	2,494	3,505	2,416	2,008	1,126	2,492	92	372	18,573
1980 budget	1,313	415	2,672	2,697	3,781	2,368	2,154	1,208	2,684	99	406	19,797

FUNCTIONAL SUMMARIES: FACILITIES SERVICES

Rental of real property:												
1978 actual		44	754	4,454	----------	1	----------					5,253
1979 bddget		77	795	4,777	----------	10	----------					5,659
1979 current		50	637	4,768	----------	110	----------					5,565
1980 budget		65	647	4,866	----------	110	----------					5,688
Maintenance and Related Services												
Maintenance, repairs, and alterations, B & G:												
1978 actual	190	1,026	1,710	411	6,965	4,571	598	1,703	2,465	----------	871	20,510
1979 budget	143	1,660	1,371	669	6,540	7,343	339	745	1,290	100	966	21,166
1979 current	127	965	1,482	644	4,674	5,519	585	901	1,984	100	946	17,927
1980 budget	129	1,048	1,504	629	6,717	6,841	624	930	2,190	100	1,072	21,784
Maintenance of equipment:												
1978 actual	85	113	38	----------	431	575	----------	93	210	----------	47	1,592
1979 budget	65	93	14	10	410	603	----------	35	94	----------	48	1,372
1979 current	62	77	15	----------	387	630	----------	75	172	----------	48	1,466
1980 budget	63	80	16	----------	394	847	----------	76	182	----------	52	1,710
Subtotal, maintenance and re-related:												
1978 actual	275	1,139	1,748	411	7,396	5,146	598	1,796	2,675	----------	918	22,102
1979 budget	208	1,753	1,385	679	6,950	7,946	339	780	1,384	100	1,014	22,538
1979 current	189	1,042	1,497	644	5,061	6,149	585	976	2,156	100	994	19,393
1980 budget	192	1,128	1,520	629	7,111	7,688	624	1,006	2,372	100	1,124	23,494

	ARC	DFRC	GSFC	HDQS	JSC	KSC	LARC	LERC	MSFC	NSTL	WFC	Total
Custodial services:												
1978 actual	1,327	1,027	2,379	123	2,335	9,287	1,538	1,802	3,155	----------	604	23,577
1979 budget	1,350	1,406	1,750	154	2,378	10,299	1,958	1,980	2,682	250	653	24,860
1979 current	1,561	962	1,842	164	2,736	10,147	1,894	1,929	2,899	242	669	25,045
1980 budget	1,640	1,015	1,972	167	3,086	12,450	1,980	2,075	3,077	246	718	28,426
Utilities:												
1978 actual	3,491	247	5,016	----------	6,145	7,589	6,012	5,314	5,945	----------	1,274	41,033
1979 budget	3,751	392	5,965	----------	8,232	9,651	7,024	6,945	6,532	----------	1,292	49,784
1979 current	4,925	394	5,584	----------	7,148	9,810	6,789	7,121	6,794	752	1,437	50,754
1980 budget	5,607	453	6,149	----------	7,470	11,173	7,588	7,813	6,946	827	1,556	55,582
Total facilities:												
1978 actual	5,093	2,457	9,897	4,988	15,876	22,023	8,148	8,912	11,775	----------	2,796	91,965
1979 budget	5,309	3,628	9,895	5,610	17,560	27,906	9,321	9,705	10,598	350	2,959	102,841
1979 current	6,675	2,448	9,560	5,576	14,945	26,216	9,268	10,026	11,849	1,094	3,100	100,757
1980 budget	7,439	2,661	10,288	5,662	17,667	31,421	10,192	10,894	12,395	1,173	3,398	113,190
FUNCTIONAL SUMMARIES: TECHNICAL SERVICES												
Automated Data Process Equipment:												
1978 actual			255	1,608	2,481	411	56	14	823	----------	40	5,688
1979 budget			276	1,800	2,249	509	101	22	803	----------	11	5,771
1979 current			276	1,279	2,266	430	106	29	800	----------	10	5,196
1980 budget			280	1,298	2,300	464	311	13	812	----------	14	5,492
Operations:												
1978 actual	296	86	1,000	3,042	2,401	2,999	2,062	182	2,509	----------	99	14,676
1979 budget	301	218	893	3,962	2,488	2,758	1,311	217	3,521	35	69	15,773
1979 current	363	218	1,010	3,597	2,115	3,296	1,275	189	2,810	35	108	15,016
1980 budget	478	261	1,070	3,752	2,540	3,456	1,368	213	2,706	35	118	15,997
Subtotal, automated dzta process:												
1978 actual	296	86	1,255	4,650	4,882	3,410	2,118	196	3,332	----------	139	20,364
1979 budget	301	218	1,169	5,762	4,737	3,267	1,412	239	4,324	35	80	21,544
1979 current	363	218	1,286	4,876	4,381	3,726	1,381	218	3,610	35	118	20,212
1980 budget	478	261	1,350	5,050	4,840	3,920	1,679	226	3,518	35	132	21,489
Scientific and Technical Information Library:												
1978 actual		1	405	86	74	342	80	44	807	----------	82	1,921
1979 budget		14	553	115	81	327	85	30	761	15	108	2,089
1979 current		14	568	181	90	349	90	43	715	6	92	2,148
1980 budget		15	576	184	96	377	101	43	720	6	104	2,222

Education and information:												
1978 actual	244	34	297	10,005	1,365	1,643	188	492	144	----------	23	14,435
1979 budget	261	49	102	9,017	688	1,750	328	231	126	----------	223	12,775
1979 current	241	60	213	9,779	671	2,018	250	157	134	----------	32	13,555
1980 budget	257	66	217	10,295	682	2,311	252	160	142	----------	175	14,557
S/T Scientific and Technical Information:												
1978 actual	244	35	702	10,091	1,439	1,985	268	536	951	----------	105	16,356
1979 budget	261	63	655	9,132	769	2,077	413	261	887	15	331	14,864
1979 current	241	74	781	9,960	761	2,367	340	200	849	6	124	15,703
1980 budget	257	81	793	10,479	778	2,688	353	203	862	6	279	16,779
Shop support and services:												
1978 actual	81	105	212	454	1,011	338	----------		1,353	----------	161	3,715
1979 budget	45	67	222	188	1,279	838	----------	65	1,207	----------	38	3,949
1979 current	82	117	179	453	1,253	351	----------		1,269	----------	104	3,808
1980 budget	174	116	182	460	1,388	379	----------		1,208	----------	113	4,020
Total, technical:												
1978 actual	621	226	2,169	15,195	7,332	5,733	2,386	732	5,636	----------	405	40,435
1979 budget	607	348	2,046	15,082	6,785	6,182	1,825	565	6,418	50	449	40,357
1979 budget	686	409	2,246	15,289	6,395	6,444	1,721	418	5,728	41	346	39,723
1980 budget	909	458	2,325	15,989	7,006	6,987	2,032	429	5,588	41	524	42,288
FUNCTIONAL SUMMARIES: MANAGEMENT AND OPERATIONS												
Administration communications:												
1978 actual	739	308	2,261	1,214	2,271	2,332	1,069	601	2,380	----------	123	13,298
1979 budget	895	346	2,475	2,284	2,737	2,351	2,147	810	2,044	35	149	16,273
1979 current	824	380	2,264	1,497	2,426	2,333	1,164	740	2,529	25	126	14,308
1980 budget	835	379	2,299	1,520	2,437	2,359	1,182	751	2,603	25	136	14,526
Printing and reproduction:												
1978 actual	106	25	331	1,043	823	3,737	182	31	451	----------	77	6,806
1979 budget	93	25	384	722	572	3,246	159	28	380	45	75	5,729
1979 current	101	35	311	1,108	750	3,468	169	5	475	45	84	6,551
1980 budget	102	36	316	1,124	761	3,706	177	5	487	47	86	6,847
Transportation:												
1978 actual	47	256	1,458	374	954	3,193	1,120	322	2,016	----------	69	9,809
1979 budget	189	203	1,652	182	814	2,941	1,337	578	1,777	35	79	9,787
1979 current	37	299	1,690	299	3,120	2,293	1,271	589	2,196	55	73	11,922
1980 budget	38	309	1,845	304	825	2,735	1,360	601	2,325	56	80	10,478
Installation, common services:												
1978 actual	1,809	892	2,711	3,398	5,357	10,084	2,653	1,318	3,223	----------	1,256	32,701
1979 budget	1,512	745	868	3,790	5,019	6,762	2,066	654	2,845	85	833	25,179
1979 current	1,636	1,221	1,245	4,015	5,000	7,614	3,058	1,275	2,684	92	871	28,711
1980 budget	1,689	1,263	1,302	4,308	5,467	8,071	3,221	1,388	2,841	97	951	30,598
Total, management and operations:												
1978 actual	2,701	1,481	6,761	6,029	9,405	19,346	5,024	2,272	8,070	----------	1,525	62,614
1979 budget	2,689	1,319	5,379	6,978	9,142	15,300	5,709	2,070	7,046	200	1,136	56,968
1979 current	2,598	1,935	5,510	6,919	11,296	15,708	5,662	2,609	7,884	217	1,154	61,492
1980 budget	2,664	1,987	5,762	7,256	9,490	16,871	5,940	2,745	8,256	225	1,253	62,449

Mr. BOLAND. I also have some questions to be answered in considerable detail for the record that have to do with the NASA computers. We will supply those questions to you, along with some additional questions with respect to your shop.

[The information follows:]

You are requesting funds for seven major computer procurements beginning in FY 1980 amounting to over $3 million. For each of these—

Since answers to certain of the questions or portions of a specific question are applicable to all seven major computer procurements, we have separated these from the other questions. Those questions that require general answers appear below.

(A) (2) Please describe the analysis process used to determine the need for the procurements.

Prior to the acquisition of any computer equipment having a purchase value or equivalent purchase value for leased equipment of $5,000 or more, an ADP equipment acquisition plan must be prepared and approved. This plan ensures that the requirements leading to the acquisition plan have been reviewed and validated and that proper planning for the equipment has been undertaken. It further ensures that the plan is in compliance with appropriate directives and management instructions, particularly the OMB requirements for feasibility and systems studies.

The plan describes in detail the requirements to be satisfied and relates the requirements to the feasibility study elements of the plan. For example, the plan may show scientific and engineering, batch processing, satellite data reduction, and digital simulation as numbers and types of operations to be performed and the level of input/output activity. The plan describes alternate solutions for meeting the requirements and the possible use of excess ADP equipment.

ADP equipment acquisition plans that have a purchase value of less than $300,000 are approved by NASA Center Directors after review by program and functional offices. Plans having a greater value than $300,000 are forwarded to NASA Headquarters for approval of the Associate Administrator for Management Operations. Prior to his approval the program or institutional offices review the plan to ensure it meets their programmatic or institutional needs. It is also reviewed by the Information Systems Division to ensure the proposed configuration is the most effective technical approach.

(B) Please describe the process for determining the funding requirements.

After the proposed configuration and component list to satisfy the requirements is determined, a lease versus purchase study is made to decide the most economical means of acquiring the equipment. The estimated purchase or lease cost of each component is then determined by using the current GSA price schedule.

(E) Please describe your experience in using a lowest total overall cost approach in acquiring the new Lewis Research Analysis Center.

The Research Analysis Center includes a new computer facility as well as the building. We are directing our response to the new computer facility since the question is concerned with new computer systems. A primary concern during the initial development of system specifications and evaluation criteria for the LeRC computer system was acquisition at the lowest overall cost to the Government. There was close liaison with industry and with GSA during the initial work and as often as appropriate during the preparation of system specifications and evaluation criteria.

A preliminary set of specifications was given to industry for review and response in order to assure a competitive action. Each of the vendor comments was addressed as to additional clarification, modifications where appropriate, and explanations when modifications could not be made. These were provided to the vendors along with release of a second set of specifications revised as appropriate. The vendor comments to this second iteration along with the revised specifications were then submitted to the GSA. As noted earlier, GSA was kept advised during the two preliminary releases to industry. It is believed that the present specifications are acceptable and a DPA from GSA is expected shortly.

(F) Please describe your projects underway to expand the use of common ADP systems.

There are three projects underway to expand the use of common "software" systems. In an effort to minimize energy costs, NASA is installing a utility con-

trol system (UCS) at the NASA centers. Common software is being developed which will operate on the similar hardware systems installed around the agency. Significant savings are expected because of the centralized development and maintenance of the UCS software. NASA has developed a standard personnel and payroll system which three centers currently use and another is in the planning stage. When centers are making major modifications to their existing personnel/payroll systems, they review the possibility of using the standard system. Several efforts have been undertaken to assess the feasibility of common business/administrative (e.g., financial management) systems. Because of dissimilar hardware and dissimilar interfacing systems, common systems are not cost-effective unless a number of centers are facing major development efforts.

There are two projects underway to expand the use of common "hardware" systems. The UCS effort mentioned above employs common hardware procured through a centralized buy. The STAR vector processor computer at Langley Research Center is utilized as a common agency resource for solving large scale computational fluid dynamics problems.

A significant feature of a long range ADP planning effort for the Office of Aeronautics and Space Technology is to determine the use which could be made of common or shared ADP systems among the affected centers.

(G) Precisely how has top management's attention been drawn to the problem of unplanned proliferation associated with distributed data processing and microprocessor technology?

One of the most active and significant elements of the NASA ADP environment is the NASA Intercenter Committee on ADP. The membership of this committee consists of a representative from each of the agency's field installations and from the Headquarters Systems Development and Operations Branch. This committee has the following designated responsibilities:

(1) Advising NASA management on the establishment of procedures, reviews, and controls necessary to insure compliance with the OMB and other Governmental policies and regulations on the selection, acquisition, and management of NASA ADP resources.

(2) Serving as an advisory group to NASA Headquarters and installations on intercenter and agency-wide procedures and operational aspects of NASA ADP.

(3) Establishing ad hoc subcommittees of NASA subject matter specialists to advise NASA management on specific problems concerning ADP.

(4) Serving as a communications medium for the rapid dissemination of ADP information to users.

In meeting its responsibilities to establish ad hoc subcommittees on specific problems concerning ADP, two such subcommittees pertinent to this inquiry have been established. These are the subcommittee on networking which encompasses the concept of distributed data processing, and the subcommittee on computer technology which has to date directed its major efforts to microprocessors and microcomputers.

The output of these subcommittees take the form of presentations at the meetings of the full committee, special briefings to NASA management, written reports and comments regarding agency management documents during their preparation.

(H) What policies are in place to prevent this problem?

The principal management documents covering the use of ADP within NASA is a NASA Handbook, NHB 2410. 1B entitled, "Computer Resources Management." This handbook has recently been subject to an extensive update and rewrite. This latest version of the handbook is scheduled for publication and release in the very near future.

Regarding microprocessors and microcomputers, a full section of the handbook and one of the appendices is fully devoted to this subject. In addition, some of the NASA centers have developed and published related documents that deal with the specific questions of microprocessor and microcomputer developments as they relate to their center. The development of documentation and application of this technology is a definite area under examination during the Headquarters staff periodic review of the agency's data processing installations.

The policies relating to distributed data processing are not yet as well defined as those associated with microprocessors and microcomputers. The subject of distributed processing is still under intense study and review by this agency and for this reason it is believed that the establishment of detailed policy and guidelines at this time would be premature. However, it should be emphasized that

the format of the soon to be released NHB 2410.1B calls for and facilitates an annual reexamination and update of that document. It is contemplated that sufficient information will be in hand to permit the inclusion of specific policy and guidance relating to distributed processing at the time of the first annual review and update.

(I) And finally, what are the positive incentives offered a NASA data processing user to make efficient use of ADP technology?

Principal positive incentive for making efficient use of ADP technology is provided through opportunity for increased productivity in the user functional area. Managers are evaluated for effectiveness in their area of responsibility based on the criteria of productivity and efficiency. ADP technology is but one tool available to potentially increase productivity and efficiency within the user functional area.

QUESTION 23 AS IT RELATED TO GODDARD SPACE FLIGHT CENTER'S CENTRAL TELEMETRY DATA PROCESSING SYSTEM

(A) (1) Please describe the requirements.

The Central Telemetry Data Processing System provides for computation and manipulation of satellite telemetry data that requires either correlative information such as ephemeris or large contiguous volumes of data and for the supporting organizations interfaces with experiments. In technical terms, the system-provided support includes annotation of playback data with respect to time as well as decommutation for the various experimenters. In addition to this, the facility provides near real time data analysis to experimenters in the immediate past launch period to verify proper experiment operations. Increased mission support will be required for FY 80 and beyond for such programs as the Solar Maximum Mission, Landsat-D, the Magnetic Field Satellite, the Stratospheric Aerosol and Gas Experiment mission, and the Severe Storms research. Additional ADP support requirements will be generated by the Climate Program, the Earth Radiation Budget Satellite mission, the Cosmic Background Explorer, the Extreme Ultraviolet Explorer, the Active Magnetispheric Particle Trace Experiment, and Upper Atmospheric Research. Processing and analysis of experiment data in greater volume must be accomplished more rapidly to make the results of more immediate value.

(A) (2) Analysis process used to determine the need for the procurements.

This question is answered in a general statement which covers all seven procurements.

(A) (3) Precise type of equipment and capacity required.

Main frame replacement for telemetry computation including interim Spacelab data processing. UNIVAC 1100/82 dual processor (1,024K 36-bit words of main memory) to replace UNIVAC 1108 dual processor (262K words of main memory).

(C) Identify the budget accounts the funding is in.

Tracking and Data Acquisitions: part from Operations Funds (10%) (i.e., leases); part from System Implementation (90%) (i.e., purchases); all from Research and Development funds.

(D) Describe the type of procurement being proposed.

Sole Source Procurement.

What are the full system life cycle costs for the procurement?

Cost for 10-year life is $4,860K.

QUESTION 23 AS IT RELATED TO GODDARD SPACE FLIGHT CENTER'S CENTRAL DATA HANDLING FACILITY

(A) (1) Please describe the requirements.

The Atmosphere Explorers are being used to investigate the photochemical processes and energy transfer mechanisms accompanying the absorption of solar ultra-violet radiation in the earth's upper atmosphere. The Atmosphere Explorers differ from the usual scientific spacecraft not only in the type of orbit but also in the team approach taken by the investigators, in the degree of interaction between the investigators and the spacecraft and data operations, and in the rapidity with which data must be forwarded, processed, and analyzed. To meet the mission objectives, a large-scale digital computer is required to provide a dedicated, data handling facility and associated remote terminals for near real time and on-line data analysis for the investigators.

For support of the projected missions, it is planned to replace the terminals now on the XDS Sigma 9/3 computer system. The terminals currently in use

at the principal investigator sites consist of an alphanumeric CRT display, printer, card reader, and controller. Experience gained to date has demonstrated that at sites where two principal investigators are located a graphics terminal is required. Studies as to optimum terminal configuration are now underway.

(A) (2) Analysis process used to determine the need for the procurement.

This question is answered in a general statement which covers all seven procurements.

(A) (3) Precise type of equipment and capacity required.

For Dynamics Explorer telemetry data analysis by experimenters, 15 terminals (11 intelligent and 4 alphanumeric) to replace old display and associated hard copy units on Sigma 9 computer. Each of the intelligent terminals includes a 16-bit microprocessor with floppy disk storage, two CRT display units (one alphanumeric and one graphics), and a printer-plotter.

(C) Identify the budget accounts the funding is in.

Office of Space Science-Physics and Astronomy Programs (Research and Development).

(D) Describe the type of procurement being proposed.

Competitive procurement.

What are the full system life cycle costs for the procurement?

Cost for 3-year life is $450K.

QUESTION 23 AS IT RELATES TO GODDARD SPACE FLIGHT CENTER'S MISSION OPERATIONS COMPUTER SYSTEM

(A) (1) Please describe the requirements.

The Mission Operations Computer System currently consists of four large scale and five medium sized third generation digital computers. The primary functions of this computing system are to perform unmanned spacecraft attitude and orbit computations, mission operations support computations, Satellite Tracking and Data Network operational support computations, and general scientific computations on a noninterference basis for GSFC.

Increased mission support will be required for FY 80 and beyond for such programs as the Solar Maximum Mission, Landsat-D the Magnetic Field Satellite, the Stratospheric Aerosol and Gas Experiment mission, Dynamics Explorer, Spacelab Data Processing, Space Telescope, and Severe Storms research.

(A) (2) Analysis process used to determine the need for the procurement.

This question is answered in a general statement which covers all seven procurements.

(A) (3) Precise type of equipment and capacity required.

Computer replacement of this system in three stages to provide support for the following functional areas: 1) Flight Dynamics and Attitude for Spacecraft, 2) Spacecraft Control and Command Management, and 3) Spacecraft Orbit Determination. The computers now supporting these areas are 1) IBM 360/95 (5, 120K bytes of main memory), 2) IBM 360/65 (2,048K bytes), and 3) two IBM 360/75s (2,048K bytes each).

(C) Identify the budget accounts the funding is in.

Tracking and Data Acquisition—System Implementation (Research and Development).

(D) Describe the type of procurement being proposed.

Three competitive procurements.

What are the full system life cycle costs for the procurement?

Cost for 10-year life for whole system supporting all three areas is $30,400K.

QUESTION 23 AS IT RELATES TO LANGLEY RESEARCH CENTER

(A) (1) Please describe the requirements.

This action is continuation of a long-range plan for refurbishment and upgrading the CDC 6600 general purpose computer complex. This is a multiprocessor facility consisting of a CDC 6400, two CDC 6600s, two CDC Cyber 73s, two CDC Cyber 175s, and a STAR 100. Critical items are the obsolete 6600 and 6400 computers and peripherals installed in the last quarter of CY66 and which are becoming increasingly unreliable and costly to maintain. This is the central computation facility at LaRC and any delays to this action will result in serious delays to the center's research work.

(A) (2) Analysis process used to determine the need for the procurement.

This question is answered in a general statement which covers all seven procurements.

(A) (3) Precise type of equipment and capacity required.

The specific equipment selected for FY 80 actions are refurbishment of the CDC 6400 computer (systems access, control), and replacement of the STAR 100 disk memory with a higher performance system.

(C) Identify the budget accounts the funding is in.

The budget account is Space Research and Technology (Research and Development).

(D) Describe the type of procurement being proposed.

These will be sole source procurements.

What are the full system life cycle costs for the procurement?

The estimated full system life cycle cost is $15 million.

QUESTION 23 AS IT RELATES TO NASA HEADQUARTERS, HEADQUARTERS CENTRAL SYSTEM

(A) (1) Please describe the requirements.

The Headquarters central system provides ADP support to all NASA Headquarters offices. This support includes institutional as well as agency-wide data systems. Institutional data systems provide ADP support to those offices concerned with operation of the NASA Headquarters as an installation. Agency-wide data systems accept input from all NASA field support to those offices concerned with the operation of NASA as an agency.

Because of the continuing increase in computational requirements (especially in the on-line, interactive terminal support area), the NASA processing capability will have to be significantly augmented in the post budget year period.

(A) (2) Analysis process used to determine the need for the procurement.

This question is answered in a general statement which covers all seven procurements.

(A) (3) Precise type of equipment and capacity required.

The present NASA Headquarters (general purpose) computer is of medium size with 4M bytes of core and a single CPU. It has been expanded to approximately 60% of its potential. It operates at near capacity during peak hours and is on a six to seven day a week schedule, 24 hours a day. At the current rate of application growth it will reach its limit of expansion in the 1981/1982 time frame after installation of an attached processor (supplemental CPU) and an additional 2M bytes of core. After that time, it will be necessary to replace the system with one of greater capacity/or to supplement it with another system. Considering productivity (including per unit cost) and the likely need for a system of this capacity elsewhere in the agency, upgrading to a new system is likely to be the most cost-effective route for the agency to take.

(C) Identify the budget accounts the funding is in.

This equipment will be acquired using research and program management funds.

(D) Describe the type of procurement being proposed.

Upgrading of the current NASA Headquarters system will be a mixture of competition and sole source. Plug-to-plug components equal in state-of-the-art and offered by various vendors will be procured through competition. Unique or advanced equipment offered by a single vendor that will increase productivity may be sole source. When the time comes to replace the system, the major components will be procured through the competitive process.

What are the full system life cycle costs for the procurement?

The life cycle cost of the present NASA Headquarters computer system begins with a current base of approximately $150,000 a year which includes some purchased and some leased hardware and operating software. This can be expected to increase approximately 20–25% a year for the duration of the present system which will be through 1981/1982. Initial start up of the follow on system may require a major outlay which, amortized over its life cycle, will probably continue at approximately 20% growth per year.

Assuming a similar life cycle duration as was experienced with the present system, the total life cycle cost for the replacement system will be $10.3 million over a 5-year projected life cycle.

QUESTION 23 AS IT RELATES TO MARSHALL SPACE FLIGHT CENTER'S HUNTSVILLE COMPUTER COMPLEX

(A) (1) Please describe the requirements.

MSFC proposed to replace the two UNIVAC 1108 computer systems in order to provide better interactive user support and increased batch processing workload. In addition to increases in Shuttle Main Engine testing and Solid Rocket Booster firings requiring computer support, new and expanded activities in premission flight evaluation preparation and Shuttle flight evaluation data base requirements will increase computer support needs.

(A) (2) Analysis process used to determine the need for the procurement.

This question is answered in a general statement which covers all seven procurements.

(A) (3) Precise type of equipment and capacity required.

The major components of the proposed systems are two CPU's 524KW, input/output channels, 32K storage unit, and 16K I/C storage expansion. In addition, there will be controllers, channels, disk drives, and other peripheral components.

(C) Identify the budget accounts the funding is in.

The Huntsville Computer Complex is multiprogram funded. The exact funding is related to the programmatic activity as MSFC. The major budget account funding the equipment will be the Space Transportation Systems Programs or the Space Flight Operations.

(D) Describe the type of procurement being proposed.

The procurement is proposed as a sole source procurement.

What are the full system life cycle costs for the procurement?

The full system life cycle cost of the Huntsville system is $4.5 million.

QUESTION 23 AS IT RELATES TO MARSHALL SPACE FLIGHT CENTER'S SLIDELL COMPUTER COMPLEX

(A) (1) Please describe the requirements.

MSFC proposed to replace the UNIVAC 1108 CPUs, memories, and add mass storage units. There will be a requirement beginning in FY 80 for increased support to Space Shuttle; specifically Shuttle External Tank fabrication. Shuttle Main Engine testing, and the Integrated Parts Scheduling System (IPSS). The IPSS will be linked to the Slidell host computer via terminals at the Michoud Assembly Facility.

(A) (2) Analysis process used to determine the need for the procurement.

This question is answered in a general statement which covers all seven procurements.

(A) (3) Precise type of equipment and capacity required.

The major components of the proposed system are two CPUs 524KW, one communications processor, 4–64K memory module, terminals, backing storage units. In addition, there will be controllers, channel expansion, disks, buffers, and other peripheral components.

(C) Identify the budget accounts the funding is in.

The Slidell Computer Complex is multiprogram funded. The funding is based on the actual use of the equipment. The major budget account funding the equipment will be the Space Tranportation Systems or Space Shuttle.

(D) Describe the type of procurement being proposed.

The procurement is proposed as a sole source procurement.

What are the full system life cycle costs for the procurement?

The full system life cycle cost of the Slidell system it $5.6 million.

RESOLUTION OF CONTRACT DISPUTE

Mr. BOLAND. Yes, Dr. Lovelace?

Dr. LOVELACE. I believe we do have the answer to your question regarding the Informatics contract, if you would like to hear it?

Mr. BOLAND. Okay.

Mr. HOSENBALL. CSC had been selected as the contractor, a protest was filed, and the investigation was conducted as requested. As a result of the investigation, CSC was "unselected," if you will, and the award was made to Informatics.

Dr. FROSCH. The allegations proved to be correct, and the contract was redirected.

Mr. BOLAND. I thought your answer was a fair one last year.

Larry?

Mr. COUGHLIN. Thank you, Mr. Chairman. I want to join in commending NASA for operating as efficiently as it does with the substantial reduction in personnel.

Will this kind of reduction in personnel continue in the next few fiscal years?

Dr. FROSCH. I hope not. I think we are getting into some considerable difficulty in keeping the proper flow of technical skills in the Agency. We are suffering from an aging problem, in the sense that the average age of personnel in the organization is increasing nearly half a year per year. This trend implies that at sometime we are going to have a massive loss of experience with the current situation of not bringing in younger people and training them.

NASA PERSONNEL PROJECTIONS

Mr. COUGHLIN. Do you have projections over the next few years as to what your personnel levels would be?

Dr. FROSCH. We hope to hold our own, but we have no projection for personnel as we do for budget. The money runs it.

We have our own projections of requirements, and those suggest that overall, we would be fairly level, and we understand what the skill changes will be. What we don't know is what will happen in the budget process year by year.

Mr. COUGHLIN. Has the number of non-permanent and/or detailees increased at all as far as personnel is concerned?

Dr. FROSCH. I don't believe it has changed.

Mr. KLINE. No, sir. As far as the detailees are concerned, we are expecting to be a little lower in FY 1980 than we are in 1979, and in temporaries we will also be at a lower level than we are now.

Mr. COUGHLIN. Last year you indicated that NASA had 19 Schedule C positions, none of which have been eliminated. It was included in the Civil Service complements. Do you still have 19 Schedule C positions?

Mr. KLINE. No, sir.

Mr. COUGHLIN. What is the difference?

Mr. KLINE. The excepted positions are excepted under an appointing authority provided in special legislation to NASA. A Schedule C type of appointment is a government-wide type of special schedule for confidential positions.

Mr. COUGHLIN. And excepted positions are peculiar to NASA?

Mr. KLINE. Yes, sir, that is a special authority granted to NASA.

Mr. LILLY. Let me point out that it is special under our own legislation. Other agencies also have special legislation.

Mr. COUGHLIN. How many such positions does NASA have?

Mr. KLINE. 425.

Mr. COUGHLIN. Why so many?

Mr. FROSCH. The authorization is for 425 in the Space Act, and that has been the mode of staffing of the more senior scientific, engineering, and administrative positions in NASA since the beginning. The authority was given in the Space Act with the intention that it be used that way, and it has been.

Mr. COUGHLIN. Will there be any reductions in Fiscal Years 1979 and 1980?

Mr. KLINE. There will be no reduction in excepted positions. Once again many of those people in these positions will be converted into the Senior Executive Service program under the new Civil Service Reform Act.

Dr. FROSCH. We expect the bulk of those in excepted positions to accept Senior Executive Service positions.

Mr. COUGHLIN. Are these included in your Civil Service complement?

Dr. FROSCH. Yes.

Mr. COUGHLIN. We see that the number of new starts in NASA is low. Would the number of NASA employees decline if you move to close one of the space centers?

Dr. FROSCH. We looked at that extensively last year, and we feel that with a reasonable projection of what is likely to happen we would not be at the point where that would be a sensible thing to do. We looked at it in terms of moving and consolidating and closing, and the way the capabilities and facilities are distributed, it simply doesn't seem logical with the current size and activity of the Agency.

Mr. LILLY. Mr. Coughlin, many people don't recognize that the number of people we have now is essentially the same number that we had before we ever started to build the Apollo.

We are the lowest we have been since 1962. In 1962 we were about 22,000 and we are heading down to 22,000 rapidly.

Mr. COUGHLIN. I would anticipate, though, that as the Space Shuttle development comes to an end, with no new starts coming up—

Dr. FROSCH. If there are no new starts. But I think that the consequences of new starts in FY 1981 or 1982 would be so significant for the Agency's activities, for the Nation's whole space program, that the question of the size of the Agency would be swept up in the question of the nature of space program.

Mr. BOLAND. Do you see anything in the future that is akin to putting a man on the moon?

Dr. FROSCH. We don't see anything on that scale in the immediate future. But we see a level of activity in the on-going programs that is likely to add up to about the equivalent of where we are now.

Mr. COUGHLIN. So just simply operating the Shuttle is not going to be the same as building it?

Dr. FROSCH. No, but it does require some work that has not been done in the past. We see that with a reasonable level of starts in science and applications and in aeronautics, and some of the technology work that should be done, that we would expect to stay something like the same size that we are now.

Mr. COUGHLIN. It seems to be almost impossible to do that unless——

Dr. FROSCH. Unless we begin some other major single program; if we had something the size of Apollo, we would probably have to increase personnel some.

Dr. LOVELACE. The Agency's total manpower level today, as we pointed out, is at about the same level that preceded the Apollo era. We built up for Apollo, and we have come down to a level of activity that the Agency is engaged in just in terms of maintaining the United States technological base.

I think we have to be careful to maintain that level. If we substantially reduce it below that level, we will be asking ourselves some very fundamental questions about the Nation's basic technological capability to ever mount anything major, much less the additional manpower that would be required to actually do that.

Mr. YARDLEY. There seems to be a suggestion that without some large new program we wouldn't have enough important, productive work to do to keep the budget level and the people level. I don't think that is the case. In our planning activities, there are many programs that need to be accomplished. We wouldn't have to invent programs to usefully employ these people.

Dr. FROSCH. If we carry out what we think is necessary in Space Applications, in Space Science, in the technology development around the Shuttle's capabilities and in Aeronautics, we would be about this size. If we began to have a slightly greater start rate in flight projects, we would probably have to grow.

Mr. KLINE. Specifically, the fellows in the second row here gave us a very dreadful time in this recent cut. Dr. Calio's department isn't growing to the level that he needs for what he thinks he has been charged to do in Applications, and for Dr. Kramer the same is true in Aeronautics, and so on down the line.

If we take care of our Shuttle commitments in terms of direct development work, and meet our other commitments, our requirements are exceeding our current levels.

Mr. COUGHLIN. Thank you, Mr. Chairman.

Mr. BOLAND. We want to thank you, Dr. Frosch, and Dr. Lovelace and Bill Lilly and John Yardley and General McGarvey, Ray Kline, Terry Finn, and all the others for your presence here the last few days, and your cooperation with this Committee.

As we have said many times in the past, you have a very challenging responsibility and a very exciting one, and, of course, an expensive one. I think the efforts of NASA over the years have enjoyed the cooperation of the Administration and the Congress for a number of good reasons.

We appreciate your presence here today. Thank you very much. Your justifications will be inserted in the record at this point. The Committee stands adjourned.

[The justifications follow:]

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES

AGENCY SUMMARY AND RESEARCH AND DEVELOPMENT

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 BUDGET ESTIMATES

GENERAL STATEMENT

The National Aeronautics and Space Administration, established October 1, 1958, conducts space and aeronautics activities for peaceful purposes for the benefit of all. NASA's activities are designed to maintain United States leadership in aeronautical and space research, technology, and utilization, and more specifically to:

-- Extend our knowledge of the Earth, its environment, the solar system, and the universe;

-- Expand the practical applications of space technology;

-- Develop, operate, and improve manned and unmanned space vehicles;

-- Improve the civil and military usefulness of aeronautical vehicles, while minimizing their environmental effects and energy consumption;

-- Disseminate pertinent findings to potential users; and

-- Promote international cooperation in peaceful activities in space.

In October 1978, the President announced the civil space policy for the next decade which will include a balanced strategy of applications, science and technology development designed to:

-- Emphasize space applications that will bring important benefits to our understanding of Earth resources, climate, weather, pollution and agriculture;

-- Emphasize space science and exploration in a manner that retains challenge and excitement and permits the Nation to retain the vitality of its space technology base;

-- Take advantage of the flexibility of the Space Shuttle to reduce the cost of operating in space;

-- Increase benefits for resources expended through better integration and technology transfer among the national space programs;

-- Assure American scientific and technological leadership in space;

-- Demonstrate advanced technological capabilities in open and imaginative ways;

-- Foster space cooperation with nations by conducting joint programs;

-- Confirm our support of the continued development of a legal regime for space that will assure its safe and peaceful use for the benefit of all.

The FY 1980 budget provides for progress in achievement of these objectives at a pace consistent with other Federal objectives and overall fiscal constraints. Basic emphasis is on effective and efficient accomplishment of currently approved programs in the practical applications of space capabilities to problems on Earth, in the exploration of space, in the expansion of human knowledge and in advancing the technology necessary to United States leadership in space and aeronautics.

The budget for FY 1980 has been developed on the assumption that a FY 1979 Supplemental Appropriation of $185.0 million will be approved to provide timely support for the Space Shuttle program. The total budget authority required for FY 1979, including this Supplemental Appropriation and the Supplemental October 1978 civil service pay raise is $4,566.2 million. The appropriations requested for FY 1980 total $4,725.0 million. Civil service staffing levels are planned at 22,831 at the end of FY 1979 and 22,563 at the end of FY 1980.

Space Shuttle

The Space Shuttle is the key element of the Space Transportation System which will open up a new era in Earth-oriented observations, scientific exploration, and technology advances. The Shuttle system will dramatically increase the capabilities and flexibility of space operations while decreasing the cost for all users -- NASA, DOD, other Government agencies, universities, commercial firms, and international groups.

Development and test of the Space Shuttle system have progressed significantly during 1978. Approach and landing tests using the orbiter test vehicle, the Enterprise, have been successfully completed and the Enterprise is now at the Marshall Space Flight Center where it is being used in conjunction with the external tank and solid rocket boosters in full system ground vibration test. The first orbiter flight vehicle is nearing completion at Palmdale, California. This orbiter will achieve the first orbital flight, which will be launched from the Kennedy Space Center. The first series of main propulsion system tests, with three engines firing simultaneously, has been completed at the National Space Technology Laboratories. The main engine has been fired more than 10,000 seconds at the rated power level of 100%. In addition, external tank and solid rocket booster flight hardware for the first orbital flight is nearing completion.

Progress at this critical phase of the Shuttle development effort has been substantial, but has not sustained the pace necessary to accomplish the plan reflected in the original FY 1979 budget. Technical problems and increased requirements in the contractor and subcontractor activities, which have been encountered as the ground test and fabrication efforts intensified, have made it necessary to adjust the program schedules and to request the supplemental appropriation in FY 1979. The FY 1980 budget request, which assumes the supplemental appropriation in FY 1979, reflects delays compared to the original FY 1979 budget plan of approximately six months in the initial orbital flight and approximately nine months in the initial operational capability.

Key areas of emphasis in the FY 1980 budget other than the Space Shuttle include:

Aeronautical Research and Technology

The FY 1980 budget continues a balanced program to provide the research and technology base required to improve aircraft performance, safety, and economy while reducing their energy requirements and environmental effects; to maintain the strong competitive position of the United States in the world marketplace; and to support the Department of Defense in maintaining the superiority of the Nation's military aircraft. The FY 1980 program focuses on:

- Strengthening the research and technology base, which is the reservoir of basic knowledge for enhancing the growth of the new and improved aeronautical capabilities on which the Nation's continued leadership in aeronautics depends.

- Continued progress in the aircraft energy efficiency efforts, which are aimed at providing, in the 1980's, the improved technology leading to a major reduction in fuel requirements for transport aircraft.

- Continued research into reducing noise and pollution and improving safety and terminal area operations.

Applications

The FY 1980 budget provides the resources to conduct a carefully coordinated and logically phased set of research and development activites that demonstrate and transfer the applications of space-based technology, systems and related capabilities for down-to-Earth, practical benefits. The FY 1980 program provides for continued progress toward these objectives in the key areas of Remote Sensing, Materials Processing and Communications. Ongoing efforts in the Remote Sensing area include: development of the Landsat-D system to advance Earth resources technology; the Earth Radiation Budget Experiment to acquire valuable data for climate studies on a global basis; and the Halogen Occultation Experiment, an instrument to provide improved pollution monitoring capabilities. These major development efforts are integrated with and based on a comprehensive

program of research and analysis to develop and demonstrate ground-based applications of the data acquired by remote sensing techniques. NASA will undertake, in conjunction with the Departments of Agriculture, Commerce and Interior, and the Agency for International Development, a program of agricultural research designed to increase our knowledge of domestic and foreign crop conditions and our commodity production estimates.

In the Materials Processing area, the FY 1980 program provides for continued development of equipment and related activities for experiments to be conducted on initial Spacelab missions and for enhancement of research activities.

In Communications, the FY 1980 program includes continued progress on the Search and Rescue Mission, augmentation of advanced communications research activities, and definition studies on an experimental wideband communications satellite to operate in the newly allocated 20/30 GHz spectral bands.

Space Science

Programs in Space Science are directed toward increasing our knowledge and understanding of life processes, the Earth and its space environment, the planets, the sun, other stars, and the universe. The FY 1980 program provides for advances in research and analysis activities and for continued progress on approved missions. These projects include: the Solar Maximum Mission, which will study solar flares and related phenomena during the peak period of the solar cycle; the Space Telescope, which will increase by several hundredfold the portion of the universe accessible for observation; the International Solar Polar Mission, a cooperative effort with the European Space Agency, which will study the polar regions of the sun and contribute to our understanding of the interactions between the sun and Earth and their effects on the Earth's weather and climate; and the Galileo mission, which will carry a probe to make the first detailed measurements of the atmosphere of the giant planet Jupiter and instruments to conduct extensive orbital observations of Jupiter and its satellites.

Space Research and Technology

The FY 1980 program provides for an enhancement of Research and Technology Base activities to provide critical advanced technology in key disciplinary areas. The program also supports systems technology efforts, including experiments to be conducted on the Shuttle Orbiter and Spacelab, the second phase of the NASA End-to-End Data System technology, and work on technology for space structures and materials, propulsion and advanced communications.

Summary

NASA's FY 1980 budget request provides for progress at a constrained pace toward the goals stated in the President's Space policy and toward maintaining United States leadership in civil and military aircraft technology.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET SUMMARY
(Thousands of Dollars)

	Budget Plan		
	FY 1978	FY 1979	FY 1980
RESEARCH AND DEVELOPMENT			
Space Transportation Systems	1,751,500	2,009,500	1,904,000
Space shuttle	1,349,200	1,628,300[a]	1,366,000
Space flight operations	267,800	309,700	467,300
Expendable launch vehicles	134,500	71,500	70,700
Space Science	404,700	505,400	601,600
Physics and astronomy	224,200	282,900	337,500
Planetary exploration	147,200	182,400	220,200
Life sciences	33,300	40,100	43,900
Space and Terrestrial Applications	243,900	283,900	344,400
Space applications	234,800	274,800	332,300
Technology utilization	9,100	9,100	12,100
Aeronautics and Space Technology	333,200	376,400	419,700
Aeronautical research and technology	228,000	264,100	300,300
Space research and technology	97,700	107,300	116,400
Energy technology	7,500	5,000	3,000
Tracking and Data Acquisition	278,300	302,000	332,800
TOTAL RESEARCH AND DEVELOPMENT	3,011,600	3,477,200	3,602,500
CONSTRUCTION OF FACILITIES	162,340	147,500	157,600
RESEARCH AND PROGRAM MANAGEMENT	889,506	941,469[b]	964,900
TOTAL	4,063,446	4,566,169	4,725,000
OUTLAYS	3,983,119	4,404,100	4,595,000

a/ Includes proposed supplemental of $185,000,000 for Space Shuttle.
b/ Includes proposed supplemental of $30,969,000 for October 1978 pay increase.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE TRANSPORTATION SYSTEMS

- Develop a Space Transportation System to provide for:
  - -- Versatile and reusable Space Shuttle system
  - -- Manned orbital experiments using Shuttle and Spacelab
  - -- Deep space and geosynchronous mission capability with upper stages
  - -- Orbital placement, servicing and retrieval of automated satellites
  - -- Economy in transportation, space operations, and payload costs
- Continue production to provide a national fleet of Space Shuttle orbiters
- Establish capability for Space Transportation System operations
- Conduct Shuttle orbital flight tests
- Conduct design and verification activities for Shuttle thrust augmentation
- Provide expendable launch vehicle services as required by NASA and other users during transition to Space Transportation System

MAJOR FLIGHT ACTIVITY

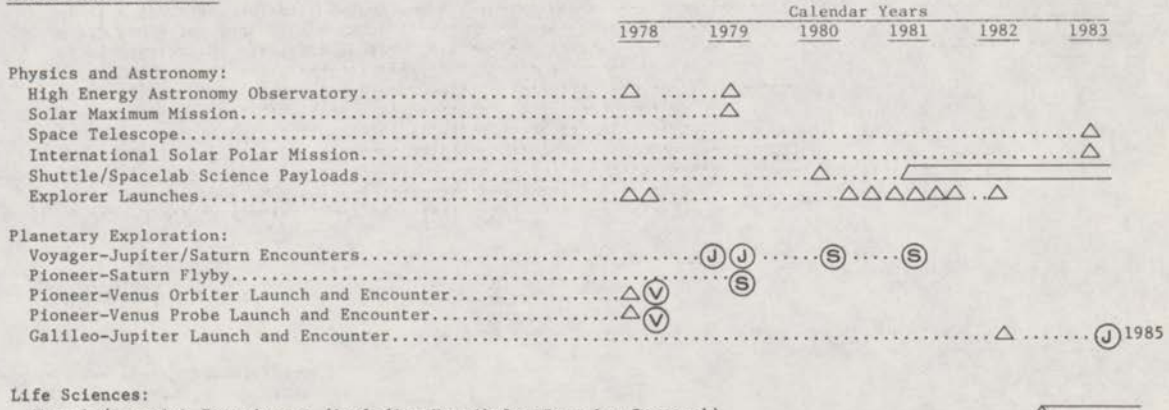


NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE SCIENCE

- Increase our understanding of the evolution and nature of the universe through a balanced program of space exploration missions and ground-based investigations
- Exploit the knowledge gained from current and completed program efforts by thorough analysis and interpretation of the scientific data obtained
- Utilize the space environment for research in the biomedical, biological, and bioinstrumentation fields

MAJOR FLIGHT ACTIVITY

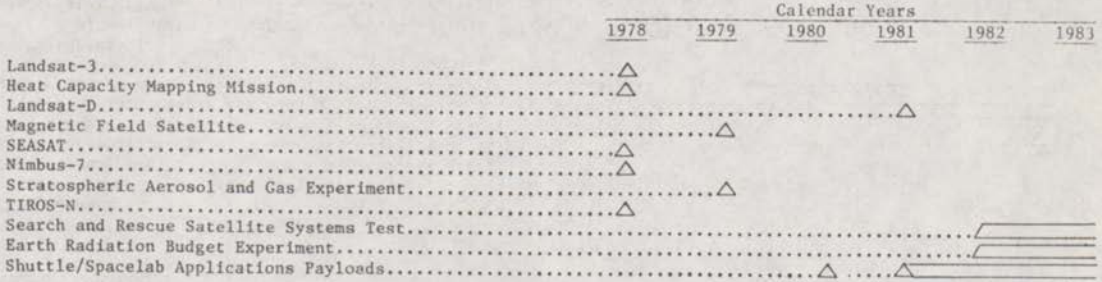


NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE AND TERRESTRIAL APPLICATIONS

- Develop and demonstrate practical uses of space and space-derived technology
  - -- Resource observations
  - -- Environmental observations
  - -- Materials processing in space
  - -- Space communications
- Accelerate the transfer of NASA-developed research and technology advances to public and private sectors

MAJOR FLIGHT ACTIVITY



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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE RESEARCH AND TECHNOLOGY

- Provide a technology base to enable and enhance future space activities by:
  - -- Improving performance
  - -- Reducing cost
  - -- Increasing reliability
- Achieve these objectives, by means of ground and space-based research and technology activities, through advances in the technology areas of:
  - -- Materials and structures
  - -- Electronics
  - -- Chemical and electric propulsion
  - -- Space power systems
  - -- Component standardization

MAJOR FLIGHT ACTIVITY

	Calendar Years					
	1978	1979	1980	1981	1982	1983
Space Technology Shuttle/Spacelab Payloads				△		

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

AERONAUTICAL RESEARCH AND TECHNOLOGY

- Provide a technology base for current and future civil and military aircraft to:
  - -- Reduce energy requirements
  - -- Improve performance
  - -- Increase safety
  - -- Decrease environmental effects
  - -- Reduce cost
- Achieve these objectives, by means of ground and flight-based research and technology activities, through advances in the technology areas of:
  - -- Materials and structures
  - -- Propulsion
  - -- Avionics and flight control
  - -- Aerodynamics
  - -- Operations
  - -- Human-vehicle interactions
- Major technology focus:
  - -- Aircraft Energy Efficiency Technology

ENERGY TECHNOLOGY

- Energy technology activities to facilitate use of NASA-developed aerospace technologies, experience and facilities to meet the program needs of the Department of Energy and other agencies responsible for energy programs

TRACKING AND DATA ACQUISITION

- Worldwide networks of ground stations interconnected with highly reliable communications to provide support to:

  -- Automated Earth Orbiting Missions - Covering an average of approximately 50 applications and scientific spacecraft, the support workload will include Nimbus 5,6, & 7, the Landsat missions, Heat Capacity Mapping Mission, International Ultraviolet Explorer, International Sun Earth Explorer missions, the High Energy Astronomy Observatory missions, and the Applications Technology Satellite missions

  -- Planetary Missions - In addition to seven Pioneer spacecraft, Helios 1 & 2 and Voyager 1 & 2 will also be supported

  -- Shuttle Orbital Flight Tests

  -- Sounding Rockets

  -- Aeronautical Flight Research Program

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES

SUMMARY OF APPROPRIATIONS
(Thousands of Dollars)

Appropriations	FY 1978 PL 95-119	FY 1979 PL 95-392	FY 1980 Request
Research and Development	3,011,600	3,477,200	3,602,500
Basic appropriation	3,013,000	3,292,200	3,602,500
Transfer to Construction of Facilities appropriation	-1,400	---	---
Proposed supplemental for Space Shuttle	---	185,000	---
Construction of Facilities	162,340	147,500	157,600
Basic appropriation	160,940	147,500	157,600
Transfer from Research and Development appropriation	1,400	---	---
Research and Program Management	889,761	941,469	964,900
Basic appropriation	844,000	910,500	964,900
Supplemental appropriation for civilian pay raises (PL 95-355)	45,761	---	---
Proposed supplemental for civilian pay raises	---	30,969	---
Total	4,063,701	4,566,169	4,725,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES

SUMMARY RECONCILIATION OF APPROPRIATIONS TO BUDGET PLANS
(Thousands of Dollars)

Fiscal Year 1978	Total	Research and Development	Construction of Facilities	Research and Program Management
Appropriation, PL 95-119	4,017,940	3,013,000	160,940	844,000
Transfer from Research and Development to Construction of Facilities	---	-1,400	1,400	---
Supplemental Appropriation, PL 95-355	45,761	---	---	45,761
Unobligated balance lapsing	-255	---	---	-255
Total Budget Plan	4,063,446	3,011,600	162,340	889,506
Fiscal Year 1979				
Appropriation, PL 95-392	4,350,200	3,292,200	147,500	910,500
Proposed supplemental for Space Shuttle	185,000	185,000	---	---
Proposed supplemental for civilian pay raises	30,969	---	---	30,969
Total Budget Plan	4,566,169	3,477,200	147,500	941,469
Fiscal Year 1980				
Appropriation request/budget plan	4,725,000	3,602,500	157,600	964,900

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES

SUMMARY OF BUDGET PLANS BY INSTALLATION BY APPROPRIATION

(Millions of Dollars)

	TOTAL			Research and Development			Construction of Facilities			Research and Program Management		
	1978	1979	1980	1978	1979	1980	1978	1979	1980	1978	1979	1980
Johnson Space Center	1,121.1	1,297.2	1,257.7	969.0	1,141.3	1,096.6	5.4	1.9	4.9	146.7	154.0	156.2
Kennedy Space Center	339.8	362.3	355.1	170.1	225.6	201.9	55.9	15.8	25.0	113.8	120.9	128.2
Marshall Space Flight Center	790.0	917.5	934.2	622.6	752.5	764.2	23.9	16.7	21.1	143.5	148.3	148.9
National Space Technology Laboratories	24.4	25.0	20.4	20.0	19.2	13.3	1.7	1.3	2.4	2.7	4.5	4.7
Goddard Space Flight Center	619.0	641.1	695.1	487.2	504.9	560.4	7.9	8.0	3.5	123.9	128.2	131.2
Jet Propulsion Laboratory	207.0	254.7	319.9	199.4	248.5	316.3	7.6	6.2	3.6	---	---	---
Wallops Flight Center	33.1	32.4	36.6	16.1	16.1	16.5	2.0	.8	3.8	15.0	15.5	16.3
Ames Research Center	185.4	235.6	248.4	112.6	128.4	140.5	15.1	43.4	42.1	57.7	63.8	65.8
Dyrden Flight Research Center	37.9	35.1	41.2	18.6	13.6	18.2	1.1	1.9	3.2	18.2	19.6	19.8
Langley Research Center	290.1	286.0	305.0	158.7	144.9	171.0	29.4	33.2	23.9	102.0	107.9	110.1
Lewis Research Center	223.7	247.9	265.8	134.6	148.3	161.4	4.2	6.6	8.6	84.9	92.5	95.8
Headquarters	186.6	219.7	230.1	102.7	133.4	142.2	2.8	---	---	81.1	86.3	87.9
Undistributed Construction of Facilities:												
Various Locations	1.8	---	---				1.8	---	---			
Space Shuttle Facilities	---	1.9	---				---	1.9	---			
Repair	---	---	.2				---	---	.2			
Rehabilitation and Modification	2.2	2.1	1.3				2.2	2.1	1.3			
Minor Construction	---	1.1	---				---	1.1	---			
Facility Planning and Design	1.3	6.6	14.0				1.3	6.6	14.0			
Total Budget Plan	4,063.4	4,566.2	4,725.0	3,011.6	3,477.2	3,602.5	162.3	147.5	157.6	889.5	941.5	964.9

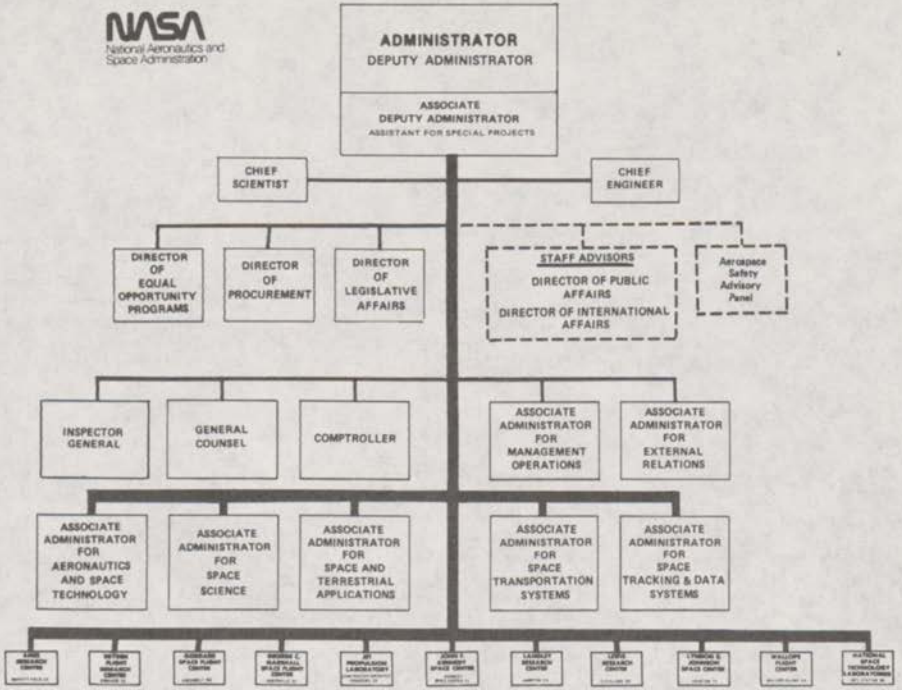
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND PROGRAM MANAGEMENT

TOTAL NUMBER OF PERMANENT POSITIONS

END OF YEAR

	FY 1978 Actual	FY 1979	FY 1980
Johnson Space Center	3,532	3,509	3,445
Kennedy Space Center	2,179	2,193	2,187
Marshall Space Flight Center	3,760	3,636	3,561
National Space Technology Laboratories	102	104	103
Goddard Space Flight Center	3,575	3,468	3,440
Wallops Flight Center	407	398	395
Ames Research Center	1,669	1,666	1,653
Dryden Flight Research Center	490	480	461
Langley Research Center	3,071	3,015	2,990
Lewis Research Center	2,921	2,858	2,835
Headquarters	1,531	1,504	1,493
Total, Permanent Positions	23,237	22,831	22,563


NASA
National Aeronautics and Space Administration
ADMINISTRATOR
DEPUTY ADMINISTRATOR
ASSOCIATE DEPUTY ADMINISTRATOR
ASSISTANT FOR SPECIAL PROJECTS
CHIEF SCIENTIST
CHIEF ENGINEER
DIRECTOR OF EQUAL OPPORTUNITY PROGRAMS
DIRECTOR OF PROCUREMENT
DIRECTOR OF LEGISLATIVE AFFAIRS
STAFF ADVISORS
DIRECTOR OF PUBLIC AFFAIRS
DIRECTOR OF INTERNATIONAL AFFAIRS
Aerospace Safety Advisory Panel
INSPECTOR GENERAL
GENERAL COUNSEL
COMPTROLLER
ASSOCIATE ADMINISTRATOR FOR MANAGEMENT OPERATIONS
ASSOCIATE ADMINISTRATOR FOR EXTERNAL RELATIONS
ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY
ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE
ASSOCIATE ADMINISTRATOR FOR SPACE AND TERRESTRIAL APPLICATIONS
ASSOCIATE ADMINISTRATOR FOR SPACE TRANSPORTATION SYSTEMS
ASSOCIATE ADMINISTRATOR FOR SPACE TRACKING & DATA SYSTEMS

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

GENERAL STATEMENT

The objectives of the National Aeronautics and Space Administration program of research and development are to extend our knowledge of the Earth, its space environment, and the universe; to expand the practical applications of space technology; to develop, operate and improve manned and unmanned space vehicles; to provide technology for improving the performance of aeronautical vehicles while minimizing their environmental effects and energy consumption; and to assure continued development of the aeronautics and space technology necessary to accomplish national goals. These objectives are achieved through the following elements:

SPACE TRANSPORTATION SYSTEMS: A program to provide all the transportation and related capabilities required to conduct space operations. The major development objective is the reusable Space Shuttle, the key element of a versatile, economical transportation system to provide a wide variety of users with round trip access to space during the 1980's and beyond.

SPACE SCIENCE: A program utilizing space systems, supported by ground-based and airborne observations, to conduct a broad spectrum of scientific investigations. The objective is to advance our knowledge of the Earth and its space environment, the Sun, the planets, interplanetary and interstellar space, as well as the other stars of our galaxy and the universe.

SPACE AND TERRESTRIAL APPLICATIONS: A program, using space, aircraft, and ground-based systems, to identify and demonstrate the useful applications of space techniques in the areas of remote sensing to acquire information which will assist in solution of Earth resources and environmental problems; advanced communications satellite systems technology; and materials processing research and experimentation. The program includes activities to accelerate the dissemination to both the public and the private sectors of advances achieved in NASA's research, technology and development programs.

AERONAUTICS AND SPACE TECHNOLOGY: A program to conduct the fundamental research and to develop the technology required to maintain United States leadership in aeronautics and space. The program also provides for identification and evaluation of elements of NASA's aeronautics and space technology which can benefit National energy programs.

TRACKING AND DATA ACQUISITION: A program, utilizing a worldwide network, to support Earth orbital, deep space, suborbital and aeronautical activities.

SPACE TRANSPORTATION SYSTEMS

Space Transportation Systems activities provide all the transportation and associated support capabilities required to conduct space operations. These activities currently focus on the development and testing of the Space Shuttle--the first reusable space vehicle and the key element of a versatile, economical Space Transportation System to provide domestic and international users with round trip access to space for the 1980's and beyond.

The Space Shuttle is the most important element of the Space Transportation System. Its versatility and reusability will open up a new era in expanding the uses of space for a wide variety of Earth applications, scientific, defense, and technological activities. The Shuttle will consist of a reusable delta-wing orbiter vehicle with three main engines, an expendable propellant tank, and reusable twin solid rocket boosters. The Shuttle will provide unique capabilities for placement and retrieval of satellites, in-orbit servicing of satellites, and delivery to Earth orbit of payloads and propulsive stages for higher altitude and planetary missions. The advent of readily available, economical transportation to and from low Earth orbit, for automated payloads, as well as for scientists and other personnel will revolutionize our concepts of using space and will expand the returns from space operations. The Shuttle's unique capabilities will not only lower the cost of space operations but will also lead to savings in the costs of payloads. These anticipated savings will result from repair and reuse of payloads and relaxation of weight and size constraints. The advantages offered by the Space Transportation System will enhance both the flexibility and the productivity of space missions compared to existing expendable launch vehicles.

Space Shuttle development is proceeding through a period of peak activity leading to initiation of orbital flight testing. Fabrication and test activities are intensifying in preparation for delivery of major flight hardware to Kennedy Space Center for the first orbital flight, which is now planned for late 1979.

The orbiter test vehicle--the Enterprise--has successfully completed the approach and landing test series and is currently at the Marshall Space Flight Center for full-scale ground vibration testing with an external tank and twin solid rocket boosters. Assembly and checkout of the first orbital flight vehicle are nearing completion consistent with delivery to the Kennedy Space Center in early 1979. This will support the start of orbital flight testing in late 1979. The orbiter structural test article has been completed and testing is in progress. After completion of these structural tests, it will be refurbished and equipped as the second orbital flight vehicle. Main engine and propulsion system testing is being conducted at the National Space Technology Laboratories, with approximately 35,000 seconds of test firings completed. The FY 1980 budget request provides for continuation of design, development, test, and evaluation activity on a schedule consistent with the major program milestones, including the planned first orbital flight in late 1979. A series of orbital flight test missions will follow. The FY 1980 program also provides for activities leading to a National fleet of four orbiter vehicles, which will include necessary modifications to the first two orbital flight vehicles and fabrication and assembly of two additional orbiters.

In summary, progress at this critical phase of the Shuttle development effort has been substantial, but has not sustained the pace necessary to accomplish the plan reflected in the original FY 1979 budget. Technical problems and increased requirements in contractor and subcontractor activities have made it necessary to adjust the program schedules and to request the supplemental appropriation in FY 1979. The FY 1980 budget request, which assumes the supplemental appropriation in FY 1979, provides for continuation of design, development, test and evaluation.

Progress on the Space Shuttle will be matched in other activities vital to the establishment of the Space Transportation System operational capability and to preparations for early operational missions. The Spacelab, which will be a multipurpose laboratory carried in the large cargo bay of the Space Shuttle, will allow scientists, researchers, and technicians to conduct their experiments in the unique environment of space. The Spacelab is being designed and built by the European Space Agency, with ten European nations participating in this development. The Inertial Upper Stage (IUS), which is being developed by the Department of Defense, will be used to deploy Shuttle-launched payloads to high energy and escape orbits. The spinning solid upper stage is being developed commercially and will be used for payloads that do not require the IUS capability. Other space flight activities related to the Space Transportation System include ground support and control equipment, multiuse mission support equipment, training equipment, and long-lead time hardware procurement to provide external tanks and solid rocket boosters for early operational missions.

Space Transportation Systems activities during FY 1980 will also provide expendable launch vehicles and services, as well as engineering support, required during the transition to the Space Transportation System.

SPACE SCIENCE

The Space Science program utilizes space systems, supported by airborne and ground-based observations, to conduct scientific investigations of the Earth and its space environment, the Sun, the planets, and interplanetary and interstellar space, as well as the other stars of our galaxy and universe. The results from these investigations significantly contribute to our understanding of the universe, including the key questions of life, matter, and energy and the complex phenomena that have such a profound effect on life and environment on Earth.

The Sun exerts a primary influence on the Earth, and its immediate environment. A series of Orbiting Solar Observatory missions have been conducted to study solar phenomena. The discoveries from these missions and from the experiments flown during the Skylab Program provide the foundation for the Solar Maximum Mission to be launched in 1979. The Solar Maximum Mission spacecraft, together with data from Explorer spacecraft and Spacelab missions, will provide scientists with an opportunity to study the Sun, including solar flares and other phenomena, during the next period of peak solar activity in 1979-1981. The International Solar Polar Mission, a joint NASA and European Space Agency mission, will be launched in 1983 to study the polar regions of the Sun--regions which cannot be observed from the Earth or from current spacecraft. To achieve the

trajectories required to study these polar regions, two spacecraft will be launched on a single Shuttle-IUS, will swing past Jupiter, and use the gravity of the giant planet to send one spacecraft toward the north pole of the Sun, and the other spacecraft toward the south pole. The measurements to be made are expected to yield previously unknown information about the Sun and its dynamics and to advance our understanding of the link between solar activity and weather and climate trends on Earth.

Development of the Space Telescope will continue to progress in FY 1980. This multiple purpose telescope will be launched by the Shuttle in 1983, and will serve as a highly versatile astronomy observatory in space for over a decade. The Space Telescope will greatly expand the volume of space accessible for observation, contributing significantly to our understanding of the origin and evolution of the universe and its energy-generating mechanisms.

Two of the three High Energy Astronomy Observatory missions have been successfully launched and are yielding important scientific information. The remaining mission is planned for launch in 1979. These missions are designed to explore the high energy phenomena observable with X-ray, gamma ray, and cosmic ray instruments. Work is also underway on Explorer spacecraft to study ultraviolet and infrared astronomy and the Sun-Earth relationships, and on payloads which will capitalize on the unique capabilities of the Space Shuttle and Spacelab.

Orderly progress in the systematic exploration of the solar system is proceeding. Two Pioneer missions to Venus were launched in 1978. One of the missions is gathering scientific data while orbiting Venus; the other carried multiple probes to give us our first detailed measurements of the hot, dense atmosphere of Venus. One interesting discovery from the atmospheric probes is that Venus has an abundance of Argon and Neon, implying that the planet may have been formed from material fundamentally different from the material that formed the Earth.

Exploration of the outer planets is also progressing. The Pioneer 11 spacecraft is approaching its rendezvous with Saturn in 1979, and Pioneer 10 is on its way to being the first spacecraft to escape our solar system. Two Voyager spacecraft, launched in 1977, are speeding toward encounters with Jupiter in 1979 and with Saturn in 1980 and 1981. These spacecraft will make scientific measurements of the two giant planets and several of their satellites. Depending on the progress of the mission, one of these spacecraft may be targeted for an encounter with Uranus. Development work will be in progress on the Galileo mission, which will be launched in early 1982 and will conduct extensive exploration of Jupiter by sampling its atmosphere with an instrument-bearing probe, by obtaining scientific data on the planet's magnetosphere and atmosphere, and by observing its satellites.

A concentrated scientific effort is underway to analyze, and bring to bear on our understanding of the solar system, the wealth of data acquired from all relevant sources, including the planetary flight missions, the Helios solar missions, the lunar flight programs, ground-based observations, laboratory investigations, and lunar sample studies.

The Life Sciences research and development program is designed to provide a basis for enhancing people's ability to work efficiently in space; to develop experiments and related equipment to be flown on Spacelab missions; and to support NASA's research into the origin and chemical evolution of life. The knowledge gained from the Life Sciences program is made available to the scientific and technical community for application and advancement of medical research, education, and technology.

SPACE AND TERRESTRIAL APPLICATIONS

The objective of the Space Applications program is to develop, demonstrate and transfer space technology, systems and related capabilities which can be applied for practical benefits here on Earth. Space Applications research and development covers the areas of Resource Observations, Environmental Observations, Materials Processing and Communications. Technology Utilization activities are designed to accelerate and expand the availability and use of technology developed in all NASA programs into the private and public sectors of the economy.

In Resource Observations, identification and monitoring by means of remote sensing from space have demonstrated new capabilities to provide data useful in such areas as agricultural assessments, water resources management, coastal zone monitoring, improvement of maps, land use and surface mine monitoring, forestry and range resources inventory, and mineral and petroleum exploration. Remote sensing activities took an important step forward with the launch in March 1978 of Landsat-3, which extends the Landsat series with improved sensors and new capabilities to acquire data in the thermal region of the spectrum. Development will continue on Landsat-D, which will have a second generation, high-resolution remote sensing instrument--the thematic mapper--and the flight-proven multispectral scanner, leading to launch in 1981. The Landsat remote sensing capabilities are being supplemented by experimental use of data from the Heat Capacity Mapping Mission, launched in April 1978. Measurements from this satellite are being applied to thermal inertia mapping and rock-type identification, with the potential for substantial contributions in oil and mineral exploration as well as in siting major civil works. Joint activities with the users continue to demonstrate specific applications of the remote sensing data in a wide variety of areas.

In FY 1980, a joint effort in agriculture research will be initiated with the Department of Agriculture, the Department of Commerce, the Department of the Interior, and the Agency for International Development. This effort will emphasize the use of remote sensing data in concert with other data sources to improve our knowledge of domestic and foreign crop conditions and our commodity production estimates.

The launch of Magsat in late 1979 will apply remote sensing to magnetic field measurements. This satellite will provide data for use by the U.S. Geological Survey to update and improve worldwide magnetic anomaly maps. One application of these maps is in long-term planning of mineral and hydrocarbon exploration. Space capabilities are also used in the development of precise measurements of the movements of the Earth's crust and other dynamic characteristics of the Earth to support research in earthquake mechanisms. A joint effort with the

United States Geological Survey, National Science Foundation, National Geodetic Survey, the Department of Defense, and with other countries, will begin to monitor the motion and internal stability of several major tectonic plates and to determine the crustal deformation in seismically active areas.

In the area of Environmental Observations, NASA is involved with the National Oceanic and Atmospheric Administration and others in improving the understanding of atmosphere and ocean processes, providing space observations of parameters involved in these processes and extending the capabilities to predict environmental phenomena and their interaction with human activities.

Areas of research and development include upper atmospheric research; global weather prediction; severe storm research; climate research; environmental quality monitoring; and oceanic processes research. This integrated approach encompasses the diverse fields of meteorology, climatology, atmospheric chemistry, atmospheric physics, and oceanography. The program focuses on the special contributions space-derived data can make in these fields.

In 1978, NASA launched Nimbus-7, an experimental air and water pollution monitoring satellite; TIROS-N, the prototype for an advanced meteorological satellite system; and Seasat, an experimental satellite with significant capabilities for observing and monitoring ocean conditions. The stratospheric aerosol and gas experiment mission to measure atmospheric constituents is scheduled for launch in early 1979. During 1978 and 1979, NASA is participating in a major global atmospheric research program experiment.

NASA, in cooperation with other Federal agencies, is participating in a national program of climate research. In FY 1980, development will continue on the Earth Radiation Budget Experiment. This satellite system is designed to measure variations in the energy exchange between the Earth's atmosphere and space and other atmospheric factors important to climate research.

Research and development will also be pursued in environmental quality monitoring and in oceanographic areas related to the remote sensing capabilities of spaceborne systems. Work will be in progress in FY 1980 on atmospheric experiments to be conducted on Spacelab missions, including an Atmospheric Cloud Physics Laboratory to conduct research into very small scale atmospheric cloud processes.

Materials Processing research and development activities are designed to exploit the unique characteristics of the space environment to achieve results which are not possible or practical on Earth. Experiments are being conducted in laboratories and with sounding rockets to build on the results of tests conducted on previous space flights and to prepare for experiments to be conducted on future Spacelab missions. Development of equipment and experiments to be used on these missions will continue in FY 1980.

Communications research and development efforts concentrate on advanced technology for communications satellite systems with significantly improved capabilities and on providing technical support and consultation to other Government agencies. In FY 1980, NASA will begin focusing on the development of technology to increase

the usable capacity of the radio frequency spectrum and of communications satellites in geosynchronous orbit, concentrating on the development of multibeam antennas and on-board switching techniques. Technical consultation activities include support of the Nation's participation in the World Administrative Radio Conference in 1979 which will reallocate worldwide usage of radio frequencies for communications activities. Development is proceeding on the search and rescue satellite system, a cooperative venture with other U.S. agencies, Canada, and France, to demonstrate improved capabilities for detecting and locating distress signals from aircraft and marine vessels.

Technology utilization activities are designed to accelerate the transfer to the nonaerospace industry, as well as State and local governments, of new knowledge and innovative technology generated by NASA and NASA contractors. During FY 1980, NASA will continue its efforts to assure effective and widespread dissemination of new technology through a variety of established mechanisms including publications, industrial applications centers, a computer software management and information center, State technology applications centers, special application teams, and applications engineering projects.

AERONAUTICS AND SPACE TECHNOLOGY

The objective of the Aeronautics program is the advancement of aeronautical technology to ensure safer, more economical, efficient and environmentally acceptable air transportation systems which are responsive to current and projected national needs. This technology is necessary to help maintain the competitive position of the United States in the international aviation marketplace and to aid the military in maintaining the superiority of the Nation's military aircraft.

Research and technology base activities concentrate on the disciplinary areas of materials, structures, propulsion, avionics, aerodynamics and human-vehicle interactions to provide advanced technology essential to meeting the future needs of civil aviation. A strong generic research and technology base is critical to continued growth and improvement in United States aeronautical capabilities. Emphasis will continue to be placed on developing the technology to improve performance, reduce energy requirements, enhance operating efficiency, reduce undesirable environmental effects, improve safety and reliability, and improve terminal area operations for a variety of aircraft types. These efforts are integrated with additional focused technology efforts to develop advanced long haul and short haul air transportation system concepts.

In the area of conventional takeoff and landing aircraft, efforts will continue to focus on aircraft energy efficiency technology aimed at providing, in the 1980's, the technology advances that will lead to a major reduction in aircraft fuel requirements. Other technology activities will include work on reduction of aircraft noise and emissions and evaluation of the suitability of broad specification jet fuels for operation in current and next generation aircraft. Rotorcraft technology efforts will continue to emphasize rotor aerodynamics, structures, avionics, flight dynamics, terminal operations and drive systems and rotor system design. General aviation activities will focus on the reduction of noise and emissions, crashworthiness

and advanced low cost avionics systems. Work on vertical takeoff and landing technology for potential future military and civil aircraft applications will be continued. Supersonic cruise research will focus on technology in the areas of propulsion, aerodynamics, structures, and controls. Research and technology efforts in the area of high performance aircraft will be conducted primarily in support of current and future military requirements.

The objectives of the Space Research and Technology program are to provide a technology base which will adequately support current and future space activities and to implement approaches for further reducing the costs of future space activities through improvement of components. The program provides a sound foundation of research and technology in the areas of materials, structures, sensing and detection, guidance and control, data reduction and distribution, chemical and electric propulsion, space energy systems and aerothermodynamics. Systems Studies will be pursued to investigate technology needs for future space missions. Systems Technology efforts in FY 1980 include continued work to develop and demonstrate the technology necessary to provide a data information and management system with an order of magnitude increase in efficiency and effectiveness from current systems. Systems Technology efforts will continue in key areas such as advanced communications, structures and materials, and propulsion.

The development and integration of experiments to be flown on early Shuttle and Spacelab missions will be continued. In 1980, experiments will be integrated into the Long Duration Exposure Facility which will be ready for integration with the Shuttle. In the Standards and Practices area, emphasis is being placed on completion of standard hardware for use on multiple missions, product improvement through component upgrading, and on improvement of program practices, concentrating on such areas as specifications, testing and flight project analysis.

Energy Technology efforts in NASA are primarily directed toward identifying the technology developed in the aeronautics and space program which has potential for making major contributions to the solution of energy problems on Earth. NASA provides technical support to the programs undertaken by other agencies to develop specific applications such as solar cells, solar heating and cooling, and electric power generation by wind power. NASA also makes its capabilities and facilities available to the Department of Energy and other agencies to accomplish energy technology activities on a reimbursable basis.

TRACKING AND DATA ACQUISITION

This program provides for continuation of tracking and data acquisition support for earth orbital spacecraft, planetary missions, sounding rockets, and research aircraft. This support is provided by a worldwide network of NASA ground stations, interconnected by a highly reliable communications system which provides the capability for instantaneous transmission of data and critical commands between spacecraft and the flight control centers. Facilities are also provided to process into meaningful form the large amounts of scientific, applications, and engineering data which are collected from flight projects.

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The FY 1980 workload will remain high, with the Spaceflight Tracking and Data Network supporting an average of approximately 50 earth orbital scientific and applications spacecraft and the Deep Space Network supporting a full complement of planetary missions. Missions to be supported by the Spaceflight Tracking and Data Network include the High Energy Astronomical Observatories, the Heat Capacity Mapping Mission, Landsat-3, Nimbus-5, 6, and 7, International Sun-Earth Explorers, International Ultraviolet Explorer, as well as international missions and missions of other U.S. agencies. The Spaceflight Tracking and Data Network will also be supporting start of the Shuttle orbital flight tests. The support workload of the Deep Space Network will continue to include the Pioneer 6-11 missions, Helios 1 and 2 and Voyager 1 and 2 as well as Pioneer-Venus.

A major aspect of the Tracking and Data Acquisition program in future years will be the Tracking and Data Relay Satellite System (TDRSS), which will support essentially all earth orbital spacecraft missions and will greatly improve NASA's earth orbital tracking and data acquisition capabilities. NASA will acquire this capability through an arrangement under which the contractor will establish the system and provide NASA with TDRSS services beginning in 1981.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

Federal Funds

General and special funds:

RESEARCH AND DEVELOPMENT*

*See Part III for additional information

For necessary expenses, not otherwise provided for, including research, development, operations, services, minor construction, maintenance, repair, rehabilitation and modification of real and personal property; tracking and data relay satellite services as authorized by law; and purchase, hire, maintenance, and operation of other than administrative aircraft, necessary for the conduct and support of aeronautical and space research and development activities of the National Aeronautics and Space Administration, [$3,292,200,000] *$3,602,500,000* to remain available until September 30, [1980] *1981*: *Provided, That contracts may be entered into under this appropriation for research and development activities to be continued thereafter (42 U.S.C. 2451, et seq.: Department of Housing and Urban Development—Independent Agencies Appropriation Act, 1979, additional authorizing legislation to be proposed.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

Program and Financing (in thousands of dollars)

Identification code 80-0108-0-1-999	Budget plan (amounts for research and development actions programed)			Costs and obligations		
	1978 actual	1979 estimate	1980 estimate	1978 actual	1979 estimate	1980 estimate
Program by activities:						
Direct program:						
1. Space transportation systems:						
(a) Space shuttle	1,349,200	1,443,300	1,366,000	1,401,475	1,408,700	1,393,500
(b) Space flight operations	267,800	309,700	467,300	256,983	306,900	445,000
(c) Expendable launch vehicle development and support	58,700	42,600	55,900	44,358	95,400	67,200
2. Scientific investigations in space:						
(a) Physics and astronomy	242,000	300,400	337,500	214,008	285,700	322,600
(b) Planetary exploration	159,500	182,400	220,200	160,382	182,000	214,500
(c) Life sciences	33,300	40,100	43,900	23,230	38,100	42,900
3. Space and terrestrial applications:						
(a) Space applications	280,500	286,200	347,100	262,421	284,900	329,000
(b) Technology utilization	9,100	9,100	12,100	7,390	10,100	11,600
4. Space research and technology	97,700	107,300	116,400	91,256	109,400	112,400
5. Aeronautical research and technology	228,000	264,100	300,300	211,137	244,000	273,100
6. Energy technology	7,500	5,000	3,000	6,457	5,700	4,000
7. Supporting activity:						
(a) Tracking and data acquisition	278,300	302,000	332,800	276,711	301,100	323,000
Total direct program	3,011,600	3,292,200	3,602,500	2,955,808	3,272,000	3,538,800
Reimbursable program:						
1. Space transportation systems:						
(a) Space shuttle	22,306	34,594	32,642	12,067	29,860	29,720
(b) Space flight operations	18,943	63,574	79,778	14,693	61,710	77,440
2. Scientific investigations in space:						
(a) Physics and astronomy	3,709	600	600	1,238	3,440	720
(c) Life sciences	433	419	408	314	470	410
3. Space and terrestrial applications:						
(a) Space applications	170,539	220,973	140,582	156,543	217,890	153,830
(b) Technology utilization	8,328	7,293	7,293	6,137	8,020	7,330
4. Space research and technology	2,646			2,084	1,170	280
5. Aeronautical research and technology	18,714	16,692	12,767	15,417	18,240	13,640
6. Energy technology	110,601	158,400	196,900	102,712	161,830	187,750
7. Supporting activity:						
(a) Tracking and data acquisition	4,213	3,655	4,130	3,565	3,570	3,980
Total reimbursable program	360,432	506,200	475,100	314,770	506,200	475,100
Total program costs, funded	3,372,032	3,798,400	4,077,600	3,270,578	3,778,200	4,013,900
Change in selected resources (undelivered orders and stores)				39,745	377,548	63,700
10.00 Total	3,372,032	3,798,400	4,077,600	3,310,323	4,155,748	4,077,600

SUM 11

General and special funds—Continued

RESEARCH AND DEVELOPMENT—Continued

Program and Financing (in thousands of dollars)—Continued

Identification code 80-0108-0-1-999		Budget plan (amounts for research and development actions programed)			Costs and obligations		
		1978 actual	1979 estimate	1980 estimate	1978 actual	1979 estimate	1980 estimate
	Financing:						
	Offsetting collections from:						
11.00	Federal funds	−243,933	−313,184	−354,740	−243,933	−313,184	−354,740
14.00	Non-Federal sources	−116,499	−193,016	−120,360	−116,499	−193,016	−120,360
21.40	Unobligated balance available, start of year: For completion of prior year budget plans:						
	Direct				−190,484	−240,403	
	Reimbursable				−105,155	−116,945	
24.40	Unobligated balance available, end of year: For completion of prior year budget plans:						
	Direct				240,403		
	Reimbursable				116,945		
	Budget authority	**3,011,600**	**3,292,200**	**3,602,500**	**3,011,600**	**3,292,200**	**3,602,500**
	Budget authority:						
40.00	Appropriation	3,013,000	3,292,200	3,602,500	3,013,000	3,292,200	3,602,500
41.00	Transferred to other accounts	−1,400			−1,400		
43.00	**Appropriation (adjusted)**	**3,011,600**	**3,292,200**	**3,602,500**	**3,011,600**	**3,292,200**	**3,602,500**
	Relation of obligations to outlays:						
71.00	Obligations incurred, net				2,949,890	3,649,548	3,602,500
72.40	Obligated balance, start of year				554,672	515,865	1,016,913
74.40	Obligated balance, end of year				−515,865	−1,016,913	−1,165,513
90.00	Outlays				2,988,697	3,148,500	3,453,900

Note—Reconciliation of budget plan to obligations:

	1978 actual	1979 estimate	1980 estimate
Total budget plan	3,372,932	3,798,400	4,077,600
Deduct portion of budget plan to be obligated in subsequent years	234,304		
Add obligations of prior year budget plans	172,595	257,348	
Total obligations	3,310,323	4,155,748	4,077,600

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

BUDGET PLAN SUMMARY

Code		FY 1978	FY 1979	FY 1980
		(Thousands of Dollars)		
	SPACE TRANSPORTATION SYSTEMS	1,751,500	2,009,500*	1,904,000
253	Space shuttle	1,349,200	1,628,300*	1,366,000
253	Space flight operations	267,800	309,700	467,300
253	Expendable launch vehicles	134,500	71,500	70,700
	SPACE SCIENCE	404,700	505,400	601,600
254	Physics and astronomy	224,200	282,900	337,500
254	Planetary exploration	147,200	182,400	220,200
254	Life sciences	33,300	40,100	43,900
	SPACE AND TERRESTRIAL APPLICATIONS	243,900	283,900	344,400
254	Space applications	234,800	274,800	332,300
254	Technology utilization	9,100	9,100	12,100
	AERONAUTICS AND SPACE TECHNOLOGY	333,200	376,400	419,700
405	Aeronautical research and technology	228,000	264,100	300,300
254	Space research and technology	97,700	107,300	116,400
254	Energy technology	7,500	5,000	3,000
255	TRACKING AND DATA ACQUISITION	278,300	302,000	332,800
	TOTAL	3,011,600	3,477,200*	3,602,500

*Includes proposed supplemental appropriation of $185,000,000 for Space Shuttle.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

SUMMARY OF BUDGET PLAN BY SUBFUNCTION

Code		FY 1978	FY 1979	FY 1980
		(Thousands of Dollars)		
253	Space Flight	1,751,500	2,009,500*	1,904,000
254	Space Science, Applications and Technology	753,800	901,600	1,065,400
255	Supporting Space Activities	278,300	302,000	332,800
(250)	Subtotal, General Science, Space and Technology	2,783,600	3,213,100*	3,302,200
402	Air Transportation	228,000	264,100	300,300
	Total	3,011,600	3,477,200*	3,602,500

*Includes proposed supplemental of $185,000,000 for Space Shuttle.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES

DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND FISCAL YEAR
(Thousands of Dollars)

PROGRAM		TOTAL	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	National Space Technology Laboratories	Goddard Space Flight Center	Jet Propulsion Laboratory	Wallops Flight Center	Ames Research Center	Dryden Flight Research Center	Langley Research Center	Lewis Research Center	HQ & Nonfacility
OFFICE OF SPACE TRANSPORTATION SYSTEMS, TOTAL	1978	1,731,906	913,447	169,312	311,067	16,105	84,734	475	---	470	760	16,274	38,903	17,756
	1979	1,909,500	1,088,916	224,393	385,467	16,391	57,150	---	---	50	1,055	15,453	16,322	28,842
	1980	1,906,000	1,031,950	200,300	367,750	9,300	67,100	---	---	---	1,500	7,300	16,400	13,150
Space shuttle	1978	1,340,200	788,743	164,011	233,988	10,000	---	---	---	265	760	126	500	11,016
	1979	*1,629,300	964,286	158,600	489,600	10,000	---	---	---	50	1,055	93	500	14,044
	1980	1,368,000	861,100	134,800	339,300	4,000	---	---	---	---	1,500	100	---	13,200
Space flight operations	1978	267,810	124,904	54,065	77,379	6,100	1,116	475	---	125	---	90	300	3,386
	1979	308,700	164,520	54,133	86,207	6,091	3,443	---	---	---	---	---	---	13,383
	1980	447,300	170,800	71,700	108,430	5,300	6,700	---	---	---	---	---	---	4,150
Expendable launch vehicles	1978	124,296	---	11,232	---	---	46,618	---	---	---	---	16,100	38,203	4,344
	1979	71,500	---	9,660	---	---	53,695	---	---	---	---	11,340	15,822	965
	1980	70,700	---	3,800	---	---	45,400	---	---	---	---	7,200	16,400	1,900
OFFICE OF SPACE SCIENCE, TOTAL	1978	404,700	22,216	81	85,473	30	88,431	83,361	4,118	35,317	140	12,495	674	48,330
	1979	503,400	28,774	400	127,510	---	94,736	134,587	4,434	42,160	183	1,130	200	67,966
	1980	601,600	23,264	838	154,111	---	90,793	184,733	5,219	47,157	288	855	---	68,625
Physics and astronomy	1978	234,290	273	---	83,384	---	84,990	9,583	4,118	15,477	---	1,495	738	10,527
	1979	282,950	330	---	123,128	---	83,577	27,511	4,434	7,338	---	1,130	300	31,761
	1980	337,500	314	---	150,111	---	74,943	58,153	5,219	4,157	---	855	---	33,625
Planetary exploration	1978	147,200	8,717	---	79	---	3,041	74,100	---	27,288	---	11,000	80	12,895
	1979	182,400	4,356	---	7,488	---	3,339	107,673	---	38,803	---	---	---	20,717
	1980	220,250	4,385	---	10	---	3,830	136,130	---	46,335	---	---	---	29,150
Life sciences	1978	33,350	13,026	81	---	30	---	1,378	---	12,552	140	---	86	5,808
	1979	40,150	16,200	400	---	---	---	1,710	---	14,317	183	---	---	7,340
	1980	43,950	14,430	838	---	---	---	2,050	---	16,480	288	---	---	5,870
OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS, TOTAL	1978	343,900	27,308	736	17,314	3,890	127,363	29,137	3,343	7,048	67	9,903	3,288	14,218
	1979	383,900	24,307	793	17,988	2,933	157,755	15,084	2,956	6,880	54	13,071	4,043	35,588
	1980	344,600	31,538	971	20,825	3,800	183,000	24,000	4,315	11,550	60	10,125	5,325	17,663
Space applications	1978	134,800	27,308	553	14,679	3,890	124,681	28,383	3,343	6,191	---	9,025	3,030	9,625
	1979	154,800	24,343	793	27,506	2,933	156,598	12,612	2,956	6,283	---	12,134	3,734	23,173
	1980	152,300	31,130	921	29,533	3,750	184,196	22,900	4,125	10,550	---	10,125	5,125	11,725
Technology utilization	1978	9,100	100	183	635	---	680	539	10	857	67	868	256	4,805
	1979	9,100	140	90	482	---	857	477	4	395	54	938	338	5,115
	1980	12,100	300	150	500	50	900	1,700	200	1,000	60	1,000	200	7,968
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, TOTAL	1978	355,320	6,074	---	8,747	---	3,353	26,877	933	49,801	14,443	118,994	91,487	9,479
	1979	374,400	7,164	---	11,259	---	7,539	27,528	619	59,319	9,067	119,268	138,167	4,306
	1980	419,700	10,148	---	8,250	---	9,300	24,750	700	41,748	13,400	142,700	139,335	7,350
Aeronautical research and technology	1978	258,000	700	---	736	---	---	1,375	933	41,100	14,423	94,862	71,050	2,881
	1979	284,100	1,243	---	956	---	---	1,310	619	48,313	9,067	93,961	104,452	3,196
	1980	302,300	700	---	900	---	---	1,100	700	31,900	13,400	113,300	113,000	3,300
Space research and technology	1978	97,320	4,499	---	8,845	---	3,353	24,051	---	8,553	48	23,132	19,028	4,234
	1979	107,300	5,001	---	8,801	---	7,539	25,018	---	10,007	---	25,287	33,333	3,313
	1980	115,400	9,448	---	6,350	---	9,300	24,400	---	9,848	---	27,400	25,430	3,900
Energy technology	1978	7,500	875	---	1,165	---	---	1,551	---	140	---	---	1,409	1,360
	1979	3,000	920	---	1,500	---	---	1,200	---	---	---	---	1,400	---
	1980	3,000	---	---	850	---	---	1,250	---	---	---	---	1,100	---
OFFICE OF SPACE TRACKING AND DATA SYSTEMS	1978	178,350	---	---	---	---	198,311	57,678	5,444	---	3,154	---	---	12,885
	1979	302,000	---	---	---	---	214,200	61,300	5,900	---	3,300	---	---	15,300
	1980	332,900	---	---	---	---	258,100	68,800	6,300	---	3,000	---	---	16,500
TOTAL BUDGET PLAN	1978	3,011,000	969,043	170,134	421,825	20,060	487,342	199,371	14,034	112,636	18,384	158,671	134,550	107,648
	1979	3,477,200	1,141,361	225,386	732,459	19,247	534,880	248,514	14,089	138,369	13,671	164,903	168,773	133,606
	1980	3,401,500	1,084,438	201,825	744,147	13,300	540,193	316,283	16,544	140,447	18,548	170,880	161,445	147,240

*Includes supplemental request of $183 million.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE TRANSPORTATION SYSTEMS

Programs	1978 Actual	Budget Plan 1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Space Shuttle	1,349,200	1,439,300	1,628,300*	1,366,000
Space flight operations	267,800	311,900	309,700	467,300
Expendable launch vehicles	134,500	76,500	71,500	70,700
Total	1,751,500	1,827,700	2,009,500*	1,904,000

*Includes proposed supplemental request of $185,000,000.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRANSPORTATION SYSTEMS — SPACE SHUTTLE PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Design, Development, Test and Evaluation	1,307,500	985,300	1,170,300*	610,500	
Orbiter	813,060	536,500	654,900	283,400	1-6
Main engine	197,400	176,700	161,400	110,600	1-9
External tank	88,030	80,500	107,600	59,800	1-11
Solid rocket booster	104,998	63,500	100,200	57,500	1-12
Launch and landing	104,012	128,100	146,200	99,200	1-14
Production	41,700	454,000	458,000	755,500	
Orbiter	29,140	397,000	344,100	590,600	1-18
Main engine	12,560	18,000	81,300	80,300	1-19
Launch and landing	---	11,000	12,400	24,600	1-19
Spares and equipment	---	28,000	20,200	60,000	1-19
Total	1,349,200	1,439,300	1,628,300*	1,366,000	

*Includes Supplemental request of $185,000,000.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Distribution of Program Amount by Installation:				
Johnson Space Center	788,743	917,900	944,396	861,100
Kennedy Space Center	104,012	140,200	158,600	124,800
Marshall Space Flight Center	433,688	361,800	499,400	359,300
National Space Technology Laboratories	10,000	5,100	10,200	4,000
Ames Research Center	345	100	10	---
Dryden Flight Research Center	760	800	1,035	1,500
Langley Research Center	126	100	93	100
Lewis Research Center	500	---	500	---
Headquarters	11,026	13,300	14,066	15,200
Total	1,349,200	1,439,300	1,628,300	1,366,000

OFFICE OF SPACE TRANSPORTATION SYSTEMS — SPACE SHUTTLE PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Shuttle is the key element of a versatile, economical space transportation system that will provide a wide variety of national and international users with round trip access to space beginning in the 1980's. The Shuttle will be the first reusable space vehicle and will be configured to carry many different types of payloads to and from low Earth orbit. Its development will provide multipurpose, economical space operations for earth applications, scientific, defense and technological payloads. The Shuttle is, however, much more than just a transportation vehicle. It will offer unique capabilities that cannot be achieved with today's expendable launch vehicles--to retrieve payloads from orbit for reuse; to service and repair satellites in space; to transport to orbit, operate, and return space laboratories; to transport materials and equipment to orbit; and to perform rescue missions. These capabilities will greatly enhance the flexibility and productivity and result in savings in the cost of space operations.

The Space Shuttle consists of four basic flight hardware elements--the orbiter, the main engines, an external propellant tank and twin solid rocket boosters--plus launch and landing systems. The orbiter is the reusable spacecraft portion of the Space Shuttle. Its large payload volume of 285 cubic meters (370 cubic yards) and cargo carrying capacity of up to 29,500 kilograms (65,000 pounds) will permit payloads to be built to less restrictive design requirements. The orbiter vehicle will carry personnel and payloads to orbit to perform their assigned tasks and return them to Earth. The orbiter is roughly the size of a DC-9 aircraft and contains three liquid fueled reusable main engines. It can provide a habitable environment for the crew, which will include scientists and engineers, for missions up to thirty days in duration.

MISSION PROFILE:

The Space Shuttle will be launched into space by the thrust of its three liquid oxygen/liquid hydrogen main engines, burning in parallel with the twin solid rocket boosters. Two minutes into the flight, at an altitude of about 45 kilometers (km) (24 nautical miles), the solid rocket boosters will burn out, separate, and descend by parachute to a soft splashdown in the ocean about 260 km (140 nautical miles) down range. They will then be recovered for refurbishment and reuse. The orbiter will continue on into space, powered by its three main engines, for another six and one-half minutes. Just before orbital insertion, the engines will be shut down and the external tank will be jettisoned. Following a ballistic trajectory,

the empty tank will reenter, tumble and break up over a remote ocean area about 18,500 km (10,000 nautical miles) down range. The orbiter, aided by its orbital maneuvering engines, will enter earth orbit to perform its mission. After completing the mission, the orbiter will again fire its orbital maneuvering engines to deorbit and reenter the atmosphere for its approach and landing.

The Space Shuttle will have a crew of three: the commander, the pilot, and a mission specialist. On some missions, up to 4 more mission or payload specialists may be added. The crew will experience forces no greater than three times that of gravity (3-g forces) during launch and landing and will be able to perform their work in a shirt-sleeve environment.

STATUS:

Space Shuttle development is in a period of peak effort and well on its way to the first orbital flight planned for late 1979. All major Shuttle system elements are proceeding in test and manufacture and all major ground test programs are now being conducted. The test elements for the Mated Vertical Ground Vibration Test (MVGVT) have been delivered to the Marshall Space Flight Center (MSFC) and testing is now in progress. This MVGVT program will verify the vibration characteristics during liftoff and at other times during the ascent profile. The tests will be completed in early 1979. The Main Propulsion Test (MPT) series started in 1978 at the National Space Technology Laboratories (NSTL) and will continue through 1979. This includes three main engines mounted on an orbiter aft fuselage and an external tank.

FY 1979 activities support preparations for the first orbital flight planned in late 1979. The Orbiter 102, which will be used for the orbital flight tests, is in final assembly and checkout at Palmdale, California. In early 1979, this orbiter will be delivered to KSC where it will begin preparations for launch. The orbiter structural test article was completed by Rockwell International and transferred to the Lockheed plant in Palmdale for structural testing, which started in 1978 and is scheduled for completion in mid-1979. Engine testing has been temporarily suspended because of an engine failure which essentially destroyed an engine. Testing will be resumed after the ongoing modifications are completed. Prior to this incident, engine testing was proceeding at a good pace, with over 5,000 seconds accumulated on one flight configured engine. The first set of flight engines will be acceptance tested at NSTL in Mississippi and, together with associated ground support equipment, will be delivered to KSC for installation on Orbiter 102 in 1979.

Fabrication of three external tank test articles has been completed, and they are being used for structural, vibration, and main propulsion testing. The second and third solid rocket motor development firings were accomplished during 1978, and the fourth and final development firing is planned for early 1979. In addition, the first solid rocket booster components for the first orbital flight were delivered to KSC during 1978.

The computerized launch processing system (LPS) at KSC in Florida, as well as the ground support equipment at KSC and at the Dryden Flight Research Center in California, are in the final stages of completion, and software validation is underway. LPS hardware deliveries have been completed, simulation support is continuing for development of checkout procedures, and checkout software is being developed. Integration of all the ground support equipment will continue and flight equipment will be checked out and processed after it arrives at KSC for launch.

To establish a national fleet of operational orbiters, Shuttle production includes fabrication of two additional orbiters, refurbishment of Orbiter 102 after its use in the orbital flight tests and early operations, and conversion of the structural test article (STA) to an operational orbiter (099). Also included are the second series of launch and ground support equipment at KSC for the simultaneous launch processing of two orbiters, and initial operational spares and equipment. Activities planned in FY 1979 include long lead orbiter subsystem hardware fabrication for converting the STA to orbital flight capability, and the start of primary structures fabrication for Orbiter 103. In addition, main engine hardware fabrication will take place and procurement of ground support equipment required for the "second line" launch capability at KSC will be initiated.

In August 1978, a detailed Space Shuttle program review was held to assess the cost, schedule and performance status. Although substantial progress has been made during this past year, the review substantiated the need to reschedule the first manned orbital flight to late 1979 and identified the requirement for additional funding in FY 1979. Testing and correction of technical problems, increased work required, mandatory changes, and necessary weight reductions have all contributed to the delay and the need for additional funds. The FY 1980 budget request is based on availability of these additional funds in FY 1979.

MAJOR PROGRAM ACTIVITIES PLANNED IN FY 1980:

- Complete main propulsion testing to support performance requirements
- Deliver the second set of main engines to KSC
- Complete delivery of four flight sets of solid rocket booster hardware for the orbital flight test (OFT) program
- Complete delivery of four external tanks for the OFT program
- Conduct the first manned orbital flight (STS-1) and continue with subsequent OFT flights
- Process development hardware for flights Nos. 2, 3, and 4
- Continue production leading to a national fleet of operational orbiters

CHANGES FROM FY 1979 ESTIMATE:

NASA is requesting a supplemental appropriation of $185 million to meet additional Shuttle development requirements in FY 1979. These requirements are a result of additional efforts necessary to solve technical problems identified in FY 1978. These include the need for expanded testing activities, schedule delays, and in general, a need for more work than was previously planned, particularly in the engineering required for systems qualification and certification and the manufacturing efforts to fabricate flight and test hardware. The FY 1980 budget request assumes approval of the proposed FY 1979 supplemental appropriation.

DESIGN, DEVELOPMENT, TEST AND EVALUATION

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Orbiter	813,060	536,500	654,900	283,400

OBJECTIVES AND STATUS:

The Space Shuttle orbiter is a reusable vehicle which serves as the orbiting spacecraft to deploy and retrieve payloads and to provide quarters for the personnel, and which reenters the atmosphere and lands as an unpowered aircraft, returning crew and payloads to the launch site. A payload of 29,500 kilograms (65,000 lbs.) can be placed in low Earth orbit at an altitude of 185 km (100 n.m.). The physical dimensions of the payload may be as large as 4.6 meters (15 ft) in diameter and 18.3 meters (60 ft) in length.

The testing required to certify Orbiter 102 for the first flight test is planned to be completed by mid-1979. The approach and landing tests with the Orbiter 101 test vehicle have been successfully completed and the objectives achieved. This orbiter is now being used in the full-scale ground vibration tests at MSFC. Assembly will be completed on Orbiter 102, which will then undergo final factory checkout and be shipped to KSC via the 747 carrier aircraft early in 1979. It will then enter the prelaunch checkout phase. During this phase, it will be stacked and checked out in support of the planned first Shuttle launch from KSC in late 1979.

The structural test article, which has a flight-type orbiter airframe, was transferred to the Lockheed test facility at Palmdale, California, in early 1978. This test article, which includes a mass to simulate the crew module, is undergoing static load testing. These tests are scheduled for completion in mid-1979, after which the STA will be converted to an orbital vehicle (099). Satisfactory completion of structural testing is required for flight loads certification of Orbiter 102.

The orbiter main propulsion test article (MPTA) was installed in the test stand at NSTL and test firings started in 1978. Testing of the three main engines, using the MPTA and an external tank, to acquire propulsion system performance data as well as acoustic data, will continue through 1979.

During 1978, a method was implemented for installing thermal protection system (TPS) tiles on the orbiter which assured maintaining the stringent step, height and gap tolerances. Problems during 1978 included difficulties in developing workforce size and skills and producing tiles with complex shapes. These problems

have hampered progress, but work has been scheduled at both the Palmdale assembly plant and at KSC to support the planned first launch in 1979. Certification testing and analysis to support the first orbital flight will be completed and flight testing will then allow definition of actual margins in the TPS system for follow-on flights.

Early orbital flight software is being used to conduct orbital flight verification tests. Initial checkout of the Palmdale and KSC test procedures, detailed evaluations of the flight control interaction with the dynamic model interfaces, and study of the remote manipulator system avionics interactions will be performed at the Shuttle Avionics Integration Laboratory (SAIL). Facility acceptance tests of the SAIL at the Johnson Space Center (JSC) with the MSFC Mated Elements System will be completed in mid-1979. This will assure that the facilities are ready to start verification of the complete avionics system and its interfaces with the Shuttle vehicle. Acceptance test of the Flight Systems Laboratory (including the Avionics Development Laboratory, Flight Control Hydraulics Laboratory, crew station, and backup flight control system flight software verifications facility) at Rockwell in Downey, California, will also be completed.

Support activities managed by JSC, including modifications to the Mission Control Center, use of crew training simulators, development of Government-furnished equipment such as space suits, and the performance of tests to support the orbiter project, will all continue. The emphasis for FY 1979 is on preparation for the orbital flight tests.

The emphasis during FY 1979 in the remote manipulator system (RMS) is the completion of operating techniques to handle payloads and the training of RMS operators. Selective simulations are being conducted to evaluate and analyze RMS operational and payload performance. Efforts are being focused on procedures for ground handling operations, RMS installation into the orbiter, and system checkout. The Canadian-funded effort will support the manufacture and integrated testing of the RMS flight hardware for the orbiter, the completion of the qualification testing, and the delivery of the first flight unit to KSC in late 1979.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The FY 1979 orbiter estimate has increased by $118.4 million. This increase resulted from additional engineering activity due to extended qualification and certification test programs, technical problems encountered on Orbiter 102, and a continuing high level of change activity. Manufacturing hours to complete the assembly and checkout of Orbiter 102 have also increased. In addition, there have been funding increases in a number of subcontracts due to development and producibility problems. Examples include thermal protection, reaction control, auxiliary power unit, and Ku-Band rendezvous radar. Other funding increases have been experienced in the orbiter support activities caused by schedule delays, and in the systems area due to necessary additional vehicle system testing planned for FY 1979.

BASIS OF FY 1980 ESTIMATE:

The orbital flight test effort, using Orbiter 102, is planned for initiation in late 1979 with the first manned orbital flight (STS-1). Analysis of this first OFT will be conducted and engineering will be provided to support follow-on development flights. During 1980, orbital flights are planned on an average of every three to four months.

Each development flight is a test to progressively support the verification of the Space Shuttle for operational use. Design certification and flight readiness reviews will be conducted before each flight to assure that there are no constraints to the specified flight mission assignment. The orbital tests are necessary to verify hardware and software operation, ground and flight procedures, system characteristics over a range of conditions, primary and backup operational modes, and overall performance. Flight test data on the systems performance will be reviewed after each flight and corrective action taken where necessary to meet operational requirements. Throughout the OFT program, engineering will be provided to perform this analysis, resolve problems and verify systems operations. These FY 1980 efforts will lead to the certification of the Space Shuttle's readiness to enter the operational phase in 1981.

After the first orbital flight, the avionics configuration verification testing will be conducted at the Shuttle Avionics Integration Laboratory and the Electronic Systems Test Laboratory with flight software programs, the remote manipulator control systems, the Ku-Band tracking radar, communications interfaces with Tracking and Data Relay Satellite System, and the S-Band payload systems interfaces. In addition, software maintenance and updating to incorporate mission-unique changes will continue throughout FY 1980. During FY 1980, the development of the remote manipulator system will be completed, and it will be flight tested during the OFT program. Post-flight analyses will also be performed.

The support activities necessary for each OFT will continue in FY 1980. The Mission Control Center will support integrated simulations with the Shuttle Mission Simulator to train the flight crews and flight controllers for these orbital flights.

MAJOR PROJECT ACTIVITIES PLANNED IN FY 1980:

- Conduct orbiter analysis of the first orbital flight test (STS-1)
- Complete certification of Orbiter 102 flight readiness for the follow-on orbital flight tests
- Deliver OFT mission kits
- Continue life demonstration tests on critical orbiter subsystems
- Support OFT flights 2-4 in preparation, data analysis, and engineering and incorporation of necessary changes.

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	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Main Engine.....	197,400	176,700	161,400	110,600

OBJECTIVES AND STATUS:

The Space Shuttle orbiter will use three high pressure liquid hydrogen/oxygen engines, each with a 2,100,000 newton (470,000 pound) vacuum thrust level. The Space Shuttle Main Engine (SSME) represents a major advance in propulsion technology and incorporates maximum utilization of existing technologies. In addition, it has the advantage of a long operating life. It will be the first large liquid fuel rocket engine designed to be reusable, and will require minimum maintenance between flights. An engine-mounted controller will be used to ensure operation within the limits of the high temperatures and pressures in the combustion cycle. Performance will be increased by using a two-stage combustion process with a high expansion ratio nozzle, which results in more efficient engine operations.

During FY 1978, problems were experienced with a number of engine components, which caused the main engine project to fall behind in accumulated engine test time. Investigation of these problems has identified failure modes and causes, and modifications are being tested. As a result, engine testing was proceeding at a good pace until a recent (December 27, 1978) failure, which destroyed most of the internal parts of an engine (2001) undergoing acceptance testing. This caused a temporary suspension of the testing. The cause of the failure has been determined and modifications are now being made to correct this problem, leading to resumption of testing in late January. Another engine is being assigned to the main propulsion test program.

Engine testing is still a pacing item to perform STS-1 in 1979. However, progress on the main engine development since the summer of 1978 has been significant. A total of 6,600 seconds at the rated power level (RPL) of 100% was achieved in one month, with over 5,000 seconds on one flight configured engine including six tests at RPL, each for the full mission duration of 520 seconds. A total of about 400 tests have been conducted accumulating almost 35,000 seconds of operation, with about 75 tests and 11,000 seconds at RPL. In addition to the two existing test stands at NSTL, an engine test stand has been activated at Santa Susana in California.

Testing will continue on flight configured engines during 1979, leading to the main engine flight certification for STS-1. The main propulsion test article, consisting of a cluster of three engines, a flight weight external tank and the aft fuselage of the orbiter, will also continue in testing during the fiscal year, and these engines will be maintained in the latest configuration. Data from main propulsion testing

will constitute a part of the engine verification. Single engine testing will also be intensive in order to prove the durability of each element of the system. Rigorous examination of each hardware component will be accomplished as a part of this thorough test activity. In 1979, the first set of three flight engines and one spare will be delivered to KSC.

In addition to the development and test work by Rocketdyne and the subcontractors, the main engine activities provide the necessary project support efforts. These efforts include the procurement of propellants for test firing the engine and its components, the maintenance of the engine systems hardware simulation laboratory, logistics support, and the evaluation of materials and processes.

By mid-1979, all necessary ground support equipment will be delivered to KSC to support installation of the first flight engines.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The main engine development estimate for FY 1979 has decreased by $15.3 million. Main engines for Orbiter 099 have been allocated to production consistent with the conversion of the orbiter structural test article (OV-099) to flight status in the production phase. This change was partially offset by development increases caused by addition of a third test stand capability to enhance development progress and some deferral of work necessitated by analysis and resolution of engine test problems.

BASIS OF FY 1980 ESTIMATE:

During FY 1980, continuing support will be provided for the orbital flight tests. This effort will include a full complement of component and full engine test capability and analytical support for the flight conditions. Fabrication, acceptance testing, and delivery of additional development test engines will be completed. Full engine testing will continue in order to meet operational power and engine life requirements. This activity includes final flight certification of the engine. During the certification program, the engine must demonstrate reliability and performance at 109% (full rated power level), and a life requirement of 3 1/2 hours and 55 starts.

The last two main propulsion test article tests are scheduled for FY 1980 to demonstrate 109% power level operation of three engines in a cluster. FY 1980 main engine funding will also support the engine systems simulation laboratory, engine software integration, and procurement of propellants for the test programs at Santa Susana and NSTL.

MAJOR PROJECT ACTIVITIES PLANNED IN FY 1980:

- o Continue full engine testing to achieve final flight certification and extended life demonstration
- o Complete fabrication and delivery of development test engines

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
External Tank (ET)	88,030	80,500	107,600	59,800

OBJECTIVES AND STATUS:

The External Tank (ET) will contain all the propellants for the orbiter's three main engines--liquid hydrogen as the fuel and liquid oxygen as the oxidizer. The liquid propellants are consumed by the orbiter's main engines from liftoff to main engine cutoff, which occurs just before the orbital insertion. Following the main engine cutoff, the ET will separate from the orbiter and tumble through a ballistic trajectory to break up over a designated remote ocean area. The ET is a single assembly approximately 8.5 meters (27.5 feet) in diameter, and 47 meters (154 feet) long. It will contain approximately 700,000 kilograms (1.55 million pounds) of propellant at liftoff. The liquid hydrogen volume is 1,530 cubic meters (54,000 cubic feet) and the liquid oxygen volume is approximately 565 cubic meters (20,000 cubic feet).

The ET is the only expendable element in the Space Shuttle system and every effort is being made to keep the unit cost to a minimum. The prime contractor's design has emphasized commonality of configuration between the tank elements in order to utilize the same tooling for the oxygen and hydrogen tanks where feasible. Six large tools are common to the fabrication of domes and barrel sections for both of the propellant tanks. Extremely lightweight, nominal one-inch thick, spray-on foam insulation will be applied to the outer surface of the external tank. Thermal ablative coating will be applied to high heat load surfaces.

Early in FY 1979, structural testing of the liquid hydrogen test tank was initiated at MSFC. This activity will be completed in 1979, along with the already started oxygen tank structural verification tests.

During the first quarter of FY 1979, the main propulsion test tank was upgraded at NSTL to a full flight configuration. A complete test tank is also being used in the full scale ground vibration tests, together with the Orbiter "Enterprise" and solid rocket boosters. This testing is planned for completion in early 1979.

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Four flight tanks are currently in various stages of assembly and checkout at the Michoud Assembly Facility (MAF) in Louisiana. Improvements in some manufacturing techniques were required, particularly with regard to the application of thermal protection materials. Some fabrication delays were encountered, and delivery of the first flight tank to KSC is now expected in the first half of 1979 to support the planned STS-1 launch. After arrival at KSC, final installations of equipment and systems checkout will take place. Completion of the ET thermal protection system application will precede the assembly of the tank into the Space Shuttle vehicle at KSC. Fabrication of the final two DDT&E flight external tanks will be initiated during FY 1979, and a second flight tank is expected to be delivered to KSC by the end of the fiscal year.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The external tank estimate for FY 1979 has increased by $27.1 million. The increase has been caused by changes due to loads and thermal analyses from wind tunnel test updates affecting structural loads and ascent heating requirements. In addition, hardware delivery delays resulted from difficulties in applying the thermal protection system to the flight tanks.

BASIS OF FY 1980 ESTIMATE:

The third and fourth development test tanks will be in the final phase of assembly and checkout at MAF and delivery is planned during the first two quarters of FY 1980. The final two development test external tanks (Nos. 5 and 6) will be in the major welding assembly tool during early FY 1980 and will phase through the thermal protection systems assembly positions, mating operations and proceed through final checkout. Delivery of these last two DDT&E tanks is planned for the second half of FY 1980.

MAJOR PROJECT ACTIVITIES PLANNED IN FY 1980:

- o Delivery of DDT&E External Tanks 3, 4, 5 and 6
- o Complete final ET installations at KSC for STS - 2, 3, 4 and 5

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Solid Rocket Booster (SRB).....	104,998	63,500	100,200	57,500

OBJECTIVES AND STATUS:

The Space Shuttle propulsion system includes two reusable solid rocket boosters which burn in parallel with the orbiter main engines to provide the necessary thrust from liftoff to booster staging. Each SRB weighs approximately 583,600 kilograms (1.29 million pounds) and delivers approximately 11.6 million newtons (2.6 million pounds) average vacuum thrust. These boosters are approximately 3.6 meters (12.2 feet) in diameter and 45.5 meters (149 feet) long and are attached to the ET. After burnout, at an altitude of about 45 kilometers (150,000 feet), they separate from the ET. The SRBs will descend by parachute and land in the ocean about 260 kilometers (140 nautical miles) from the launch site. They will be recovered by ship and returned for refurbishment and reuse.

The main element in the solid rocket booster system is the solid rocket motor (SRM), which is being developed by Thiokol, Wasatch Division, Utah. The other booster system elements such as the recovery system, thrust vector control, attach structures, forward and aft skirt, and separation motors are being procured separately. MSFC will perform designated systems integration tasks and has the responsibility for total systems integration of the solid rocket booster effort.

In 1978, the parachute drop test program consisting of six drop tests, was successfully completed. Qualification test firings of the booster separation motors occurred during 1978 and that test program is scheduled for completion early in 1979.

The electrical and instrumentation test program was completed in FY 1978 and manufacture of flight systems is proceeding. Verification testing of the thrust vector control system will continue into early 1979.

The SRB structural test program was initiated at MSFC and testing will continue in 1979. The SRB hardware required for the mated vehicle ground vibration test was also delivered to MSFC in 1978.

In addition to conducting qualification and verification testing, in mid-1979, the booster assembly contrator, United Space Boosters, Incorporated, will complete activation of the Refurbishment Subassembly Facility at KSC leading to assembly and checkout of the SRB for the first orbital flight.

During 1978, two more development motors were loaded and test fired. The development motor test series will be completed with the fourth and final development motor test planned for early 1979. The solid rocket motor qualification test series of three flight configured motors will also be fired in FY 1979.

Concurrent with the development motor testing in 1978, five ground test articles were manufactured and shipped to MSFC for tests. One SRB was used for structural testing and four (two empty and two inert loaded) for vibration testing. The manufacture of the first set of flight motors started during 1978. Shipment of the flight set of two SRMs to KSC for STS-1 will be completed by mid-1979.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The solid rocket booster estimate for FY 1979 has increased by $36.7 million. This increase was caused primarily by subsystem design changes particularly in the structures, integrated electronics, and recovery subsystems. Additional funds were also required for solid rocket motor design changes resulting from analysis of the development motor firings data.

BASIS OF FY 1980 ESTIMATE:

During FY 1980, manufacture and assembly of the SRB structural systems will be completed for the DDT&E flight hardware. In addition, the assembly of the main and drogue parachutes will be completed for the final orbital development flight. The solid rocket motors for the last development flights will be manufactured at Thiokol and delivery of four sets to the launch site will be accomplished. The booster assembly contractor will assemble and checkout the SRBs for flight missions and will be involved with refurbishing and checkout of recovered hardware for use in subsequent flights.

MAJOR PROJECT ACTIVITIES PLANNED IN FY 1980:

- o Deliver four sets of flight hardware to KSC for the orbital flight test program
- o Complete assembly and checkout of flight SRBs at KSC for the OFT program

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Launch and Landing	104,012	128,100	146,200	99,200

OBJECTIVES AND STATUS:

The Space Shuttle launch and landing project includes the preparation of a series of Space Shuttle landing, ground processing and launch station sets at KSC and the Dryden Flight Research Center (DFRC) in California, and their operation through the approach and landing test and orbital flight test phases. These station sets include handling, testing, and servicing systems and ground support equipment. At KSC, the Launch Control Center contains the heart of the computerized automated launch processing system (LPS), which connects to many of the above stations for remote monitoring and control of the vehicle testing, servicing, checkout and launch processing.

Approximately 1,430 design models of ground support equipment (GSE) for station sets have been defined, including some 810 provided by the vehicle development contractors and 620 provided by separate KSC GSE procurements. All of the GSE is on contract. About 55% of the development contractor GSE and 90% of the KSC GSE have been received. A major portion of the effort remaining in FY 1979 involves receiving the remaining GSE, installing and checking it out, and activating the resulting station sets.

All hardware and system software for the central data subsystem have been accepted. All major launch processing system operating software releases have been made to support the ground checkout software programs required for launch operations.

During 1979, the final phase of construction of facilities required for the first orbital flight will be completed. The launch processing system will be ready for mating with ground support equipment. All station sets in the first flow processing line will be activated and will complete operational readiness checkout before the first set of flight hardware reaches each respective station. Launch operations procedures will be prepared and verified for this same readiness schedule. Orbiter 102, the first flight sets of main engines and solid rocket boosters, and the first flight ET will be delivered to KSC starting in early 1979.

The development contractors' support activities and manpower buildup at KSC will continue and reach a peak during late 1979. The development contractors constitute the bulk of the launch team and are also the operators of the launch processing station sets, launch support equipment and the GSE. Processing of the vehicle for the first orbital flight will commence early in 1979. Flight elements will be assembled, checked out, serviced and launched for the first manned orbital flight. In addition, launch processing of some elements of the follow-on orbital flight tests will be in progress during 1979.

The development contractors' onsite launch support efforts at KSC have been initiated with Rockwell International (including both orbiter and main engine contractors), Martin Marietta,United Space Boosters, Inc., and Thiokol. These contractors are preparing specifications, procedures and test documentation for vehicle assembly, test, servicing, checkout and launch.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The $18.1 million increase in the FY 1979 estimate is due to the deferral of effort from FY 1978 and increased requirements in FY 1979. Due to the delay in shipment of the first flight elements to KSC, efforts such as ground support equipment (GSE) procurement, installation and checkout; propellant purchases; and launch processing system equipment buys were deferred into FY 1979. In addition, more replenishment spares were required, and the effort required to activate the various station sets (such as the orbiter processing facility, hypergolic system maintenance facility, and SRB disassembly area) was greater than previously planned.

BASIS OF FY 1980 ESTIMATE:

During 1980, the principal activities at KSC will focus on processing flight elements for the follow-on DDT&E orbital flight tests. After STS-1, the orbiter, which will land at DFRC, will be ferried back to KSC for reprocessing. In addition, the SRB's and parachutes used in this first flight will be recovered and disassembled for refurbishment and reuse.

Prelaunch processing of all elements required for the 2nd, 3rd and 4th orbital flights will be completed. Throughout this period, ground processing activities will be analyzed to reduce the vehicle turnaround time.

Site activation for all DDT&E Shuttle facilities are expected to be completed at KSC by FY 1980. Development contractors' support activities at KSC will also continue during this period. They will perform most of the launch operations for orbital flights STS-2, STS-3 and STS-4 and will operate the vehicle processing equipment throughout the launch site. In addition, planning will continue to achieve the increased launch rate capability required during the operational years.

MAJOR PROJECT ACTIVITIES PLANNED IN FY 1980:

- o Process flight elements for the orbital flight tests after STS-1
- o Conduct the first four orbital flight tests
- o Retrieval, recovery and processing of the reusable flight hardware from the orbital flight tests
- o Assess ground processing activities to improve the vehicle ground turnaround time

PRODUCTION

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Orbiter	29,140	397,000	344,100	590,600	1-18
Main engine	12,560	18,000	81,300	80,300	1-19
Launch and landing	---	11,000	12,400	24,600	1-19
Spares and equipment	---	28,000	20,200	60,000	1-19
Total	41,700	454,000	458,000	755,500	

OBJECTIVES AND STATUS:

Shuttle production provides for modification of the orbiter structural test article to orbital flight configuration (Orbiter 099), refurbishment of Orbiter 102 after the orbital flight tests and early operations period, and the fabrication and assembly of two additional orbiters to establish a national fleet of operational orbiters. Production activities also include fabrication of main engines, preparation of the second series ("second line") of Shuttle ground processing and launch support equipment at KSC to permit simultaneous processing of two Shuttle vehicles and the necessary Shuttle spares and equipment required to establish the initial inventory to support the operational flight rate capability of the Space Shuttle.

During FY 1979, the structural test program being performed at Palmdale, California, utilizing the orbiter structural test article (STA) airframe, will be completed. The test data will be used to certify the structural capability of the orbiter. After completion of the planned structural testing, which completes the development program requirements for the STA, it will be returned to the Rockwell plant at Palmdale to be converted to an orbital configuration (Orbiter 099). These modifications will consist of the removal of specific elements and instrumentation required during testing; installation of a flight-type crew module; addition of functional subsystems such as the orbital maneuvering system, the reaction control system, the atmospheric revitalization system, and the flight control and communications systems; and the application of the thermal protection system.

Fabrication and assembly of the major subsystems of Orbiter 103, which is scheduled for delivery to Vandenberg AFB early in FY 1983, has begun at Rockwell International and at the major structural subcontractors. The crew module and the forward and aft-fuselage elements are in assembly at Rockwell, and the wings, the vertical stabilizer, and the mid-fuselage are in assembly at Rockwell's subcontractors. Fabrication of the thermal protection system tiles has also begun. Some long lead ordering of critical parts will also be accomplished for Orbiter 104 during FY 1979. Efforts will be initiated during FY 1979 to identify and define a weight reduction program for implementation on Orbiters 099, 103 and 104. During FY 1979, NASA plans to negotiate a contract with the Canadians for remote manipulator flight systems, auxiliary equipment, and product support for the production orbiters. Funds appropriated for FY 1979 to maintain the option for possible fabrication of a fifth orbiter will also be used to begin procurement of critical long lead items. NASA will only order items which are common to a four or five orbiter program and not specifically for a fifth orbiter.

FY 1979 funding provides for continuation of long lead material and component procurements for those additional flight engines required for the operational orbiter fleet. Engine component procurements include hot gas manifold and preburner body forgings, turbopump castings, main combustion chamber parts and selected raw materials and plate stock for engine component fabrication. In addition, fabrication of

liquid hydrogen and liquid oxygen high and low pressure turbopump components has been initiated and assembly of the first set of production engines will be started during FY 1979. Eventually, each subsystem of each engine will be individually tested up to its operating limits before being certified as flight ready and assembled into the complete engine.

Following completion of the Main Propulsion Test (MPT) program, the MPT engines will be returned to Rocketdyne to be refurbished for use with the production orbiters.

In order to provide the "second line" capability required at KSC during the operational years, the procurement of necessary additional ground and launch support equipment has been initiated during FY 1979. This equipment will be installed in the Orbiter Processing Facility and the Launch Control Center. NASA has also initiated the procurement of flight crew equipment for the extravehicular mobility unit (space suit), communications equipment, and the portable oxygen system. In addition, procurements for ET and solid rocket booster rate tooling will be initiated later in FY 1979.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The current FY 1979 estimate has been increased by $4.0 million reflecting the action of the Congress in appropriating funds to maintain the option for a fifth orbiter vehicle. In addition, the production funding has been rebalanced to accelerate procurement of the follow-on production main engines as recommended by the Covert Committee and to provide funds in production for engines assigned to Orbiter 099.

BASIS OF FY 1980 ESTIMATE:

Orbiter

Modification of Orbiter 099 to orbital flight configuration will continue during FY 1980 for delivery to KSC in 1981. Fabrication of a new crew module and other major subsystems, such as the orbital maneuvering system and the reaction control system, will be continued for assembly into Orbiter 099.

During FY 1980, fabrication of the major structural elements for Orbiter 103 will continue. These activities will include the aft fuselage, crew module, wings, and TPS tiles. In addition, manufacture will be initiated on subsystems such as the orbital maneuvering system, reaction control system, flight control and communications systems, and environmental control systems.

In FY 1980, fabrication will begin on the fourth flight vehicle, Orbiter 104, which is planned for delivery to KSC in FY 1984. The efforts will consist of continuing the procurement of long lead items such as basic materials and forgings by the major structural subsystem contractors. Selected subassembly vendors with a long lead time fabrication cycle will also continue manufacturing hardware for Orbiter 104. The weight saving activities initiated in FY 1979 will be continued during FY 1980 to support Orbiter 099, 103 and 104 deliveries.

In FY 1980, remote manipulator system (RMS) production will also continue in order to provide the arms, spares and ground support equipment for follow-on operational use.

Main Engine

Production engine materials and component procurement will continue during FY 1980. Component deliveries such as forgings, turbopumps, main combustion chamber parts, and other engine parts will be phased to support the fabrication and assembly operations. Fabrication and assembly of engines for installation into Orbiter 099 will be completed and delivered to KSC during FY 1980. Fabrication and assembly of engines for installation into Orbiter 103 will be well underway by the end of FY 1980. An early delivery of production engines was recommended by the Covert Committee to provide additional hardware in the event it is needed for development testing. All engines will also undergo acceptance testing at NSTL before delivery to KSC.

Launch and Landing

The capability at KSC to support simultaneous launch processing and checkout of two orbiter vehicles requires the procurement of additional ground and launch support equipment. In FY 1980, the procurement of this "second line" capability will be continued. The FY 1980 efforts will increase for ground support equipment purchases, installation in the Orbiter Processing Facility Bay No. 2 and the two remaining high bays of the Vehicle Assembly Building, modifications to the second mobile launch platform, and installation of launch processing system equipment in the Launch Control Center's second firing room.

Spares and Equipment

Shuttle spares and equipment include orbiter flight and ground support equipment spares, main engine spares, KSC launch site ground support equipment spares and crew equipment. Solid rocket booster and ET rate tooling required to increase the rate of production during the operational years is also provided.

During FY 1980, NASA will initiate procurement of flight spares for the required orbiter subsystems and main engine component spares, and will continue purchasing tooling for the solid rocket booster and ET increased production rate required for future operational years.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRANSPORTATION SYSTEMS — SPACE FLIGHT OPERATIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Space transportation systems operations capability development	65,400	110,500	109,300	128,600	2-3
Development, test and mission support	171,900	163,000	160,000	172,600	2-15
Advanced programs	10,000	5,000	7,000	13,000	2-21
Space transportation system operations	16,500	33,400	33,400	153,100	2-23
*Planning and program integration	4,000	---	---	---	
Total	267,800	311,900	309,700	467,300	
Distribution of Program Amount by Installation:					
Johnson Space Center	124,904	152,900	144,520	170,800	
Kennedy Space Center	54,065	53,650	56,133	71,700	
Marshall Space Flight Center	77,379	93,500	86,207	208,450	
National Space Technology Laboratories	6,100	5,900	6,092	5,500	
Goddard Space Flight Center	2,116	1,950	3,465	6,700	
Jet Propulsion Laboratory	475	50	---	---	
Ames Research Center	125	50	---	---	
Langley Research Center	50	50	---	---	
Lewis Research Center	200	50	---	---	
Headquarters	2,386	3,800	13,283	4,150	
Total	267,800	311,900	309,700	467,300	

*Beginning with FY 1979, this effort is funded within the Space Applications program.

OFFICE OF SPACE TRANSPORTATION SYSTEMS — SPACE FLIGHT OPERATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Flight Operations program includes Space Transportation Systems Operations Capability Development; the common support activities conducted under Development, Test and Mission Support; Advanced Programs; and Space Transportation System Operations.

Space Transportation Systems (STS) Operations Capability Development provides for space transportation system development other than the Space Shuttle and payload and operations support activities. These development and support activities are necessary to facilitate the planning and orderly transition to STS operations, which will provide the means for expanding capabilities in space while reducing the cost of operations. Principal areas of activity include the Spacelab, the STS Upper Stages, Multimission and Payload Support Equipment, Mission Control Center Upgrading (Level II), Payload and Operations Support (including Skylab Reboost/Deorbit) and Thrust Augmentation.

Development, Test and Mission Support provides the common engineering, scientific and technical support required at the Johnson Space Center, the Kennedy Space Center, the Marshall Space Flight Center, and the National Space Technology Laboratories for Space Transportation Systems research and development activities.

The Advanced Programs effort provides technical as well as programmatic data for the definition and evaluation of potential future space missions and systems. In support of this effort, advanced development activities are conducted to obtain significant performance reliability improvements and reduce future program risks and development costs through the effective use of new technologies.

Space Transportation System Operations will provide the transportation services and operational activities to bring about a new era in capitalizing on the unique advantages of space to achieve expansion of human knowledge and practical benefits on Earth. The Space Transportation System Operations activities integrate the Space Shuttle system, the Spacelab, and the Upper Stages into a versatile and economical system; accomplish mission planning; provide the operational recurring hardware and consumables; and support all launch, flight recovery, crew and related activities.

Space Transportation System (STS) Operations Capability Development

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Spacelab	21,600	39,000	39,000	58,800	2-5
Space transportation system upper stages	8,400	16,500	16,500	18,300	2-7
Multimission and payload support equipment	5,378	10,000	10,600	9,600	2-9
Mission control center (MCC) upgrading (Level II)	5,400	13,000	13,000	16,000	2-11
Payload and operations support	24,622	32,000	30,200	10,900	2-11
(Skylab reboost/deorbit)	(18,500)	(20,500)	(20,500)	(---)	---
Thrust augmentation	---	---	---	15,000	2-13
Total	65,400	110,500	109,300	128,600	

OBJECTIVES AND STATUS:

The Space Transportation Systems Operations Capability Development activity includes six major areas of effort: Spacelab, Space Transportation System Upper Stages; Multimission and Payload Support Equipment; the Mission Control Center (MCC) Upgrading (Level II); Payload and Operations Support including Skylab Reboost/Deorbit, and Thrust Augmentation.

The Spacelab is a major element of the Space Transportation System. The program is being carried out jointly by NASA and the European Space Agency (ESA). NASA's support of ESA's Spacelab development effort includes development of support equipment not provided by ESA. Other activities include procurement of flight hardware, and system activation activities which assure Spacelab compatibility with the orbiter and which will lead to an operational capability.

The STS Upper Stages, which consist of the Inertial Upper State (IUS) and the Spinning Solid Upper Stage (SSUS), are an integral part of the Space Transportation System. They are expendable, propulsive stages required to provide the capability to deploy Shuttle-launched payloads to high energy orbits not attainable by the Shuttle alone. The IUS, being developed by the Department of Defense, is a multi-stage, solid propellant expendable vehicle which will become operational in 1980 on a Titan launch. The first Space Shuttle/IUS launch is planned for early 1981 (Tracking and Data Relay Satellite System). The IUS will be used for delivery of up to 5,000 pound payloads to geosynchronous orbit and for high energy planetary missions. The Spinning Solid Upper Stages (SSUS), being developed by the McDonnell Douglas Corporation as a commercial venture, are spin-stabilized,

solid propellant expendable upper stages sized to be used for Delta and for Atlas-Centaur class payloads to be launched into geosynchronous orbit. The SSUS will become operational in 1980.

Multimission and Payload Support Equipment consists of ground and flight hardware used for interfaces between the payloads and the space transportation system, as well as test equipment to verify payload integration compatibility. This class of hardware will be developed into a standard, reusable inventory for a variety of payloads.

The Mission Control Center Upgrading (Level II) is the reconfiguration of the Johnson Space Center Mission Control Center to support the STS operational flight schedule requirements. Level II will provide additional hardware, equipment, and software required for configuring the MCC to provide the capability to support two simultaneous orbiter missions, ground simulation network, and an MCC-launch site interface.

The Payload and Operations Support activity consists of four major areas of effort: Operations Management Support, Orbital Flight Test (OFT) Payload Integration, Payload Operations Control Center (POCC) and Skylab Reboost/Deorbit. The Operations Management support efforts are focused on determining the most efficient method of operating the space transportation system. The Orbital Flight Test Payload Integration provides for integrating payloads on the OFT flights during the 1979-1980 period. The POCC, to be located at the Johnson Space Center, will provide facilities for command and control of Shuttle/Spacelab attached payloads. The Skylab Reboost/Deorbit activities which were intended to provide a capability to adjust the orbit of Skylab with a Teleoperator Retrieval System (TRS) during the orbital flight test phase of the Shuttle program are being terminated. The prime contract for the TRS development was terminated in December 1978; however, selective subsystem contracts will be completed. This work should be completed by mid-1979. At that time, residual Skylab Reboost/Deorbit funds will be applied to Shuttle related activities.

Thrust Augmentation is the definition of requirements to provide the additional thrust necessary to insure full Space Shuttle system payload deployment capability of orbiter missions launched from the Vandenberg Air Force Base. Of the possible Thrust Augmentation options studied, the concept of adding a small strap-on solid rocket to each solid rocket booster was the approach selected. Adding strap-on solids to the external tank will be investigated as a capability growth option.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The STS Operations Capability Development estimate has decreased by $1.2 million. Specific changes are explained within each project.

BASIS OF FY 1980 ESTIMATES:

FY 1980 Spacelab funds are required for fabrication and test of the crew transfer tunnel and for ground support equipment. In addition, continuation of NASA program efforts are required for testing of Spacelab

during the verification flights; continuation of work on unique hardware to support the Spacelab in the Shuttle orbiter cargo bay and studies to assure compatibility of Spacelab and Shuttle. Funding is also required for incremental procurement of flight hardware from the European Space Agency (ESA), and procurement of initial spares to support early Spacelab missions.

STS Upper Stages funds are required in FY 1980 for continued development of NASA-unique hardware and software to support IUS mission planning and implementation. Funds will also be used for integration planning and system verification of the Spinning Solid Upper Stages.

FY 1980 funding for Multimission and Payload Support Equipment is required to complete development of the trace gas analyzer and the payload specialist station (PSS); initial design of the mixed cargo support hardware; activation of the first set of cargo integration and test equipment (CITE); initial design and development of the CITE dual capabilities and mission kit equipment; and checkout of the self-contained payload containers.

FY 1980 funding is required to support continued progress in upgrading the Mission Control Center at the Johnson Space Center, including completion of the design specifications for multi-vehicle command and control software and related systems and the initiation of systems integration and testing.

In addition, FY 1980 funds are required to activate the Payload Operations Control Center in support of orbital flight test payloads, as well as integration of hardware and software activities for these missions. Operations Management Support will continue to focus on alternative modes of operating the Space Transportation System (STS), as well as payload retrieval operations techniques, the analyses of STS user reimbursement policies, ground and flight operations analyses, and selected hazard analysis studies. The baseline flight planning activities for orbital flight tests will be completed in FY 1980, including the necessary safety reviews, integrated cargo loads and thermal analyses, and ground and launch operations activities.

No funding is required in FY 1980 for Skylab Reboost/Deorbit.

Thrust augmentation funding in FY 1980 is required for systems engineering, testing and engineering analyses to determine performance of the thrust augmentation concept as well as the thermal and loads impact on the total Shuttle system and facilities.

	1978	1979		1980
	Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
Spacelab	21,600	39,000	39,000	58,800

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OBJECTIVES AND STATUS:

The Spacelab is a major element of the Space Transportation System. The program is being carried out jointly by NASA and the European Space Agency (ESA) to provide a versatile, reusable space laboratory which will be flown to and from Earth orbit in the cargo bay of the Shuttle. The Spacelab will consist of a pressurized module and unpressurized pallet segments which can be used in various combinations to support mission requirements. It will permit researchers to personally conduct a wide range of experiments in a ground-type laboratory while operating in the unique environment of space.

Ten European nations, of which nine are members of the European Space Agency, are participating in the program. NASA and ESA are committed to bear the cost of their respective program responsibilities. ESA responsibilities include the design, development, production and delivery of the first Spacelab and associated ground support equipment to NASA, and the capability to produce additional Spacelabs. NASA funding responsibilities include development of flight and ground support equipment not provided by ESA, development of Spacelab operational capability and procurement of additional hardware needed to support NASA's missions.

In FY 1979, fabrication of the crew transfer tunnel will be continued. This tunnel will link the Spacelab module to the Shuttle orbiter cabin. Manufacture, test and validation of verification flight instrumentation equipment which includes sensors, electronic measuring and monitoring devices, and related flight and ground support equipment required to verify the performance of Spacelab subsystems and to monitor the environment to which payloads will be subjected, will also be continued.

Much of the U.S. developed ground support equipment will be completed in the latter part of FY 1979. The Software Development Facility will become operational in late FY 1979. The equipment in this facility, including a Spacelab command and data management subsystem computer with interfacing equipment and spares, will be used for maintenance of the software that ESA is developing, as well as for developing the application software for each Spacelab mission. Manufacture of the Spacelab training simulator, will also be continued. The simulator will be used at the Johnson Space Center to train flight controllers and flight crews in systems activation, control, and monitoring; it will also be used to support the development and verification of flight procedures. The adaptation of engineering pallet structures with systems being developed for use on some of the Shuttle orbital flight test missions will be completed in FY 1979.

In FY 1979, the Spacelab integration contractor will perform systems engineering, logistics planning, systems software preparation, and analytical experiment integration to prepare for the orbital flight tests in late 1979-1980, and the two Spacelab verification flights scheduled for 1981 and 1982.

In addition, the procurement of follow-on Spacelab hardware will be initiated in FY 1979 with the European Space Agency.

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CHANGES FROM FY 1979 BUDGET ESTIMATE:

There is no change in the FY 1979 estimate, although Congressional action on the FY 1979 budget request reduced the funding by $1.2 million on the assumption that the proposed barter arrangement would be successful. The $1.2 million has been restored to Spacelab to accommodate increased requirements because of failure to consummate a barter agreement. This funding was provided from elements of Payload and Operations Support.

BASIS FOR FY 1980 ESTIMATE:

The FY 1980 funding is required for incremental procurement of flight hardware from ESA, and the procurement of initial spares to support early year flight activities. During FY 1980, effort will be continued on development of the ground support equipment to be provided by NASA. Ground support equipment requirements include unit testers required for preinstallation checkout and subsequent fault isolation of electronic equipment; transportation equipment required to load and unload Spacelab elements from transporter aircraft; positioning equipment to handle heavy components within the modules during ground operations; and outfitting the workstands in the operations and checkout building, and equipment to support the integration and checkout of the Spacelab during ground operations.

In FY 1980, the subsystem development and verification of the orbiter and Spacelab avionics interface will be continued at the Johnson Space Center. Development of the experiment computer operating system will be completed. During 1980, the upgraded engineering model pallets will be flown on two of the orbital flight test missions.

In addition, FY 1980 funding is required to continue integration contractor efforts at the Marshall Space Flight Center and the Kennedy Space Center. Examples include support of systems engineering, systems software, logistics and analytical integration activities, design engineering support, preparations for systems preflight and postflight processing, payload integration, and preparations for postflight Spacelab disassembly and refurbishment for subsequent reuse.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Space Transportation System (STS) Upper Stages.....	8,400	16,500	16,500	18,300

OBJECTIVES AND STATUS:

The Space Transportation System (STS) Upper Stages are required to provide the capability to deploy Shuttle-launched payloads to orbits not attainable by the Shuttle alone. These Upper Stages are the Inertial Upper

Stage (IUS) and the Spinning Solid Upper Stage (SSUS) required for delivery of payloads to geosynchronous orbits and for high energy missions, such as planetary exploration missions.

The Inertial Upper Stage is being developed by the Department of Defense (DOD). It is a multi-stage, solid propellant expendable vehicle and will be operational in 1980. NASA is coordinating the incorporation of the NASA-unique and other non-DOD requirements with the DOD during the design, development, test and evaluation phase to insure IUS operations compatibility with the Space Transportation System. The IUS will be used for delivery of up to 5,000 pound payloads to geosynchronous orbit and for high energy lunar and planetary missions.

The Inertial Upper Stage (IUS) payload capability exceeds the capability needed by many geosynchronous payloads using today's expendable launch vehicles. The Spinning Solid Upper Stage (SSUS) is being developed commercially for these smaller payloads in two weight classes. The Delta-Class (SSUS-D) will be capable of injecting 1,250 pound payloads into geosynchronous transfer orbit, while the Atlas Centaur Class (SSUS-A) will be capable of injecting 2,250 pound payloads into the same orbit. The SSUS-A and SSUS-D offer the user community launch cost economies. These relatively low cost upper stages have simple physical and functional interfaces for payloads and facilitate an early and orderly transition from the current expendable launch vehicles to the operational STS. Two SSUS-A's or four SSUS-D's with their spacecraft can be flown on a single Shuttle flight. As a result, the launch costs to the user are significantly reduced.

During FY 1979, DOD will continue the IUS full scale development phase. NASA's IUS funding will support the NASA-unique hardware and software items, including mission related hardware and software, ground support equipment, operations support and IUS/STS integration and simulation/training.

The Spinning Solid Upper Stages (SSUS) are being developed by the McDonnell Douglas Corporation as a commercial venture. Funding for the SSUS program in FY 1979 supports the SSUS operations capability development effort necessary to accommodate the commercially developed SSUS-A and SSUS-D systems. This effort includes planning, analyses, preparation for ground processing and flight operations and procurement of hardware and services for the initial SSUS flight in 1980.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 STS upper stages funding is required to continue to support the development of the NASA-unique IUS configurations. This effort includes modifications to the basic DOD IUS hardware and airborne support equipment. In addition, the funding will support the development of NASA IUS launch site ground operations capability; IUS/orbiter integration analyses and testing; and the development of IUS mission planning and flight operations capability. The first NASA IUS mission is planned for 1981.

FY 1980 funding is also required for system verification of the SSUS, procurement of hardware and services, and support of Shuttle integration analysis, mission and flight operations planning and ground operations planning. The first SSUS flight is planned for 1980 on an orbital flight test mission.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Multimission and Payload Support Equipment.....	5,378	10,000	10,600	9,600

OBJECTIVES AND STATUS:

Multimission and Payload Support Equipment consists of equipment required to integrate and check out payload elements, and a class of ground and flight hardware that will provide an interface between the payloads and elements of the Space Transportation System (STS). These requirements can be furnished more economically from a standardized equipment inventory than by individual payload users. This reusable equipment is being developed to integrate, check out, transport, and operate a wide range of applications, science, and technology payloads. The equipment will support activities such as payload checkout, STS/payload integration and ground operations at the launch and recovery site, and orbital payload operations.

Examples of this type of standardized equipment are:

(1) Payload Transportation Equipment - The Super Guppy will be procured in FY 1979 for cross-country transportation of payloads (regular and outsized) to and from the Kennedy Space Center and the Western Test Range. Intrasite payload equipment is also being developed for use at the launch site to move integrated cargoes to and from the Shuttle orbiter.

(2) Payload Specialist Station Equipment - This equipment is required to conduct payload operations from the orbiter's aft flight deck. A concept utilizing existing technology has been defined and will satisfy the majority of payload functional command and display requirements, as well as mixed cargo integration and operations on early space transportation system missions. This approach will minimize the need for payload-unique equipment and operational changeout time.

(3) Mixed Cargo Support Equipment - This equipment will provide maximum flexibility for mixing cargoes in the orbiter bay, as well as decreasing installation and checkout time. The use of identical equipment for different payload configurations will allow simple crew interface and training. Examples of this equipment include standard cable harnesses which will allow command and data feedback simultaneously from up to four payloads in the orbiter cargo bay; and timing buffers which will provide various time signals to the Shuttle attached payloads while they are active.

(4) Flexible Multiplexer/Demultiplexer - The flexible multiplexer will combine the orbiter data stream and up to five separate payload telemetry or command data streams into a single output signal. The function

of the flexible demultiplexer is to separate the combined data signal, either telemetry or command, back into the appropriate orbiter or payload data streams.

(5) Cargo Integration and Test Equipment (CITE) - This equipment is required to integrate and checkout payload elements as they are assembled into a complete cargo to be flown on the Space Transportation System. CITE will verify the compatibility of the cargo to Shuttle interfaces, and assure that cargo elements do not interfere with each other.

(6) Trace Gas Analyzer - The trace gas analyzer system will perform in-flight monitoring of the aggregate "offgassing" constituents from payloads and metabolic sources in the Spacelab pressurized module. Its primary subsystems consist of a gas chromatographic column to detect the presence of an atmospheric substance and a mass spectrometer to measure the concentration of each of the atmospheric constituents.

(7) Mission Kits - The mission kits consist of standard and optional flight hardware designed to extend the capabilities of the payload and/or the orbiter to support the mission as dictated by the payload requirements. Examples of these items are self-contained payload containers and nitrogen tanks.

FY 1979 funding is being used for the continued design and development of the payload specialist station; the self-contained payload containers; intrasite payload transportation equipment; the trace gas analyzer and to complete the development of the flexible multiplexer/demultiplexer. Manufacturing and testing of the structural/mechanical cargo integration and test equipment will be completed in FY 1979, and the procurement of the Super Guppy for transporting payloads will also be accomplished.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The $600 thousand dollar increase from the budget estimate is a net increase resulting from the addition of the Super Guppy for air transportation, offset by rephasing and minor baseline changes for various items including deferring portions of the trace gas analyzer development efforts and rephasing and decreasing payload specialist station equipment requirements.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding is required to continue manufacture and testing of the trace gas analyzer and the payload specialist station. FY 1980 funds will support the design and development of the mixed cargo support equipment and mission kits. The first set of cargo integration and test equipment (CITE) will be activated in FY 1980 and the procurement of spares will be completed. The FY 1980 funding will also support the checkout of the self-contained payload containers.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Mission Control Center (MCC) Upgrading (Level II).....	5,400	13,000	13,000	16,000

OBJECTIVES AND STATUS:

Mission Control Center (MCC) Upgrading (Level II) is the reconfiguration of the Johnson Space Center Mission Control Center to support the STS operational flight schedule requirements. MCC Level I, funded under the Shuttle development program, provides hardware, equipment and software to configure the MCC to support Shuttle development flights. MCC level II will provide hardware, equipment, and software to upgrade the MCC with the capability to support two simultaneous orbiter missions, a ground simulation network, and a MCC-launch site interface.

In FY 1979, the definition of the overall system requirements will be completed. Design specifications for multi-vehicle command and control software, data distribution, display control, and flight planning systems will be finalized. Implementation of these systems will commence in support of early flight control configuration requirements. Procurement and installation of hardware for vehicle command and control, and display control will be initiated.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding is required to complete the design specifications for multi-vehicle command and control software and related systems and to initiate systems integration and testing. Software development, including the design, checkout and testing of the trajectory, telemetry and command software systems, will be continued. Communications interface equipment such as air-ground voice, telemetry processing, wide band switching and data handling equipment will be procured and installed. In addition, display, control, and data distribution equipment, such as console TV monitors and modules, computer interface multiplexers and initial equipment for the text and graphic system, will be provided in FY 1980.

Payload and Operations Support.....	24,622	32,000	30,200	10,900
(Skylab Reboost/Deorbit).....	(18,500)	(20,500)	(20,500)	(---)

OBJECTIVES AND STATUS:

The Payload and Operations Support activity consists of four major areas of effort: Payload Operations Control Center (POCC); Operations Management Support; Orbital Flight Test (OFT) Payload Integration; and Skylab Reboost/Deorbit.

The Payload Operations Control Center, to be located at the Johnson Space Center, will provide for command and control of payloads that operate in the Shuttle and Spacelab. It will operate in conjunction with the JSC Mission Control Center. Funding is required for the design and development of computers, displays, communication links, and associated software. In FY 1979, system level requirements definition and design will be completed. The POCC will become operational in conjunction with the Mission Control Center Upgrading (Level II).

Operations Management Support will focus on defining the most efficient mode of operating the Space Transportation System (STS). In FY 1979 the definition of STS user requirements, flight kit planning, analysis of STS cost per flight, analysis of payload data retrieval, and range safety studies will be continued.

The Orbital Flight Test (OFT) Payload Integration provides for the integration of payloads on the OFT flights during the 1979-1980 time period. The activities involved include management integration such as planning, scheduling, and coordinating all elements; interface definition in environmental, structural, and thermal areas; safety analysis; hardware integration; flight support; and development of the interface control document. The FY 1979 funds support conceptual flight planning, launch site planning, and thermal and loads analysis for payloads to be flown on the Shuttle orbital flight test missions.

The primary objective of the Skylab Reboost/Deorbit was to provide NASA with the capability to adjust the orbit of Skylab. This capability was to be provided by a Teleoperator Retrieval System that would allow either of two maneuvers: boost the Skylab into a higher orbit to extend its orbital lifetime, or provide the impulse to guide Skylab reentry into a predetermined remote ocean area. In December 1978, after a reassessment of the Skylab Reboost/Deorbit program, NASA discontinued plans for reboosting or deorbiting Skylab because of a limited chance of success. Three major factors which led to this decision were: (1) general deterioration of systems aboard the Skylab and consequently the unlikelihood of continuous operation through the February/April 1980 time period; (2) tight turnaround time between the first and second orbital flight test missions if the first manned orbital flight test is delayed; and (3) the probable delay in the TRS delivery schedule. The FY 1979 funding will support the termination of the TRS prime contractor effort, but will allow selective subsystem contracts to be completed. This work should be completed by mid-1979. At that time, any residual Skylab Reboost/Deorbit funds will be applied to Shuttle-related activities. Pending final closeout requirements, the FY 1979 budget estimate has not been revised.

CHANGES FROM FY 1979 BUDGET ESTIMATES:

The Payload and Operations Support budget in FY 1979 has been reduced by $1.8 million. Of this amount, $600 thousand has been allocated to Multimission and Payload Support Equipment to support the Super Guppy procurement. In addition, $1.2 million has been restored to Spacelab to accommodate increased requirements because of failure to consummate a barter agreement.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding for the Payload Operations Control Center (POCC) will support continued development of hardware and software systems to allow payload command and control and some data review and analysis. The POCC will also provide limited support to the orbital flight test payloads in the late 1979-1980 time period.

FY 1980 funding for Operations Management Support is required to continue definition of user requirements, analysis of STS cost per flight, definition of ground and flight operations techniques, and safety studies.

Orbital Flight Test Payload Integration funding in FY 1980 is required for the integration and handling of payloads for the OFT missions in the late 1979-1980 time period.

No funding is required in FY 1980 for Skylab Reboost/Deorbit.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Thrust Augmentation.....	---	---	---	15,000

OBJECTIVES AND STATUS:

Additional thrust is necessary to ensure that the full Space Shuttle system payload deployment capability of 32,000 pounds and 25,000 pounds retrieval capability can be achieved for the 98° inclination, 150 NM circular shuttle mission launched from Vandenberg Air Force Base. The current projected capability is not sufficient to perform this mission. Payloads requiring the full lift capability have been identified. Therefore, to prevent the need for maintaining large expendable launch vehicles, it is necessary to develop a thrust augmentation. During 1978, a number of possible thrust augmentation options were studied, and the selected approach is the addition of a small strap-on solid rocket motor to each solid rocket booster (SRB). The addition of strap-on solid rocket motors to the external tank will be investigated as a capability for a growth option; the external tank strap-ons would be ignited after SRB separation.

BASIS OF FY 1980 ESTIMATE:

In order to achieve the necessary operational capability in 1984, effort must begin in FY 1980 to study the impact of the thrust augmentation on each element (orbiter, external tank, and solid rocket booster), as well as the impact on the overall system and launch facility. A full implementation decision can be deferred until FY 1981; however, funds in the amount of $15 million in FY 1980 will be required for analyses and initial design activities.

This work will include systems engineering tests, wind tunnel and model tests, structural and aerodynamic loads analyses, and studies to identify the performance of the strap-on solid rocket motors. The FY 1980 effort will also consist of systems engineering activities to understand the aerothermal, structural, dynamic, and vibro-acoustic impact of the strap-on motors on the external tank and solid rocket boosters. Facility requirements will also be studied.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

DEVELOPMENT, TEST AND MISSION SUPPORT

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Research and test support	44,846	40,000	40,000	41,900	2-16
Data systems and flight support	45,562	49,300	46,300	47,000	2-17
Operations support	43,954	38,800	39,900	39,500	2-18
Launch systems support	37,538	34,900	33,800	44,200	2-19
Total	171,900	163,000	160,000	172,600	

OBJECTIVES AND STATUS:

Development, Test and Mission Support provides the common engineering, scientific and technical support required to conduct ongoing and proposed space transportation systems research and development at the Johnson Space Center, the Kennedy Space Center, the Marshall Space Flight Center and the National Space Technology Laboratories. Development, Test and Mission Support (DTMS) functions include research and test support, data systems and flight support, operations support, and launch systems support. These common efforts are necessary to support early project definition; to provide engineering support for indepth technical examination of development efforts of prime and major subcontractors on space transportation systems projects; to provide common support equipment and supplies; and to perform backup design, testing and analysis in high technology areas of design and development.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease of $3 million in the FY 1979 budget estimate for Development, Test and Mission Support is the result of Congressional authorization action.

BASIS OF FY 1980 ESTIMATE:

FY 1980 DTMS funding provides for the common engineering, scientific and technical support required for all Space Transportation Systems programs. This support is required for activities performed under Space Shuttle, Space Transportation Systems Operations Capability Development, and Advanced Programs.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Research and Test Support	44,846	40,000	40,000	41,900

OBJECTIVES AND STATUS:

Research and Test Support encompasses a broad spectrum of technical, engineering, scientific, reliability and quality assurance, and safety operations. These activities complement the work of the major development contractors located across the country in contractor-owned plants and government facilities.

BASIS OF FY 1980 ESTIMATE:

During FY 1980, research and test support efforts will be focused primarily on critical Space Shuttle activities including the orbital flight test activity. Also supported will be design and development activities under STS Operations Capability Development, and research and development efforts in Advanced Programs. Engineering and test support is provided to assure achievement of technical goals as they related to each program.

Examples of FY 1980 Space Shuttle support to be provided at the Johnson Space Center include: (1) support of the Shuttle avionics integration laboratory for ascent, on-orbit and abort mission phases of the Shuttle avionics system; (2) continuing support of the communications and tracking systems space-to-ground compatibility and performance testing; and (3) analysis and certification of government-furnished equipment, environmental control life support systems, structural and propulsion subsystems and crew station training through utilization of mockups, neutral buoyancy crew station trainers and the remote manipulator facility.

At the Marshall Space Flight Center, FY 1980 funding provides for: (1) support of the Shuttle main engine static test firing activities and integrated component testing, as well as the qualification of the main propulsion system; (2) refurbishment efforts for the solid rocket booster hardware; (3) engineering support for the Shuttle orbital flight test activity; and (4) flight evaluation of the Shuttle external tank, solid rocket booster, Space Shuttle main engine and related systems.

FY 1980 research and test support funds are also required at the Johnson Space Center and the Marshall Space Flight Center to support Space Shuttle certification inspections, tests, configuration control panels, and integration efforts.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Data Systems and Flight Support	45,562	49,300	46,300	47,000

OBJECTIVES AND STATUS:

Data Systems and Flight Support efforts are associated with the ground-based flight data systems, flight simulation systems, special purpose and general purpose data systems, and flight support.

The ground-based flight data systems effort supports the definition, design, implementation, and checkout of hardware and software modifications to the Johnson Space Center's Mission Control Center, including the real time computer complex and the Shuttle Data Processing Complex in support of the Shuttle orbital flight tests, as well as operation and maintenance of those facilities in preparation for operational mission support.

Flight simulation efforts include modification, operation and maintenance of the full-mission (both fixed-base and motion-base) and the part-task simulators which are used for flight crew training and for flight procedures development and validation for the development flight programs. Also included is the operation of the JSC central data computation facility and special purpose data system required to support Center-wide activities in mission analysis, systems engineering development, and test functions for the Shuttle program.

Flight support provides for development of Shuttle flight control and recovery plans and procedures, flight plans, flight data compilation, crew procedures and training, and other elements of the data base required for crew activities, operation and maintenance of the T-38 training aircraft, flight data management, and support of Shuttle payload accommodation and integration.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The FY 1979 data systems and flight support funding was decreased by $3.0 million because of the Congressional authorization reduction.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding of ground-based flight data systems supports the upgrading of the Mission Control Center and provides flight support and flight data management functions for the orbital flight test effort. This effort

will also include the operation of the software development laboratory, comprised primarily of the real time computer complex system required to develop and validate the Shuttle orbiter flight software.

FY 1980 efforts in flight simulation and development data systems will intensify in support of operations of both the fixed-base and motion-base simulators required for the high fidelity crew training. Data processing in the central computing facility will continue in support of mission and systems design and performance studies for the Shuttle. Flight support and flight data management functions in the orbiter data reduction complex and the Shuttle program information management system will continue in support of the orbital flight test effort.

Aircraft operations activities which will be supported in FY 1980 include maintenance, modification, and engineering support services relating to the T-38 training aircraft. FY 1980 funding requirements also provide for the flight control, crew training and engineering support of flight operations planning control for the orbital flight test missions.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Operations Support	43,954	38,800	39,900	39,500

OBJECTIVES AND STATUS:

Operations Support provides for contractor effort and related supplies and equipment to operate and maintain onsite activities at the Johnson Space Center, the Marshall Space Flight Center, the Kennedy Space Center, and the National Space Technology Laboratories, and for offsite operations at the White Sands Test Facility.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

Operations Support funding for FY 1979 was increased by $1.1 million to meet additional requirements for facility operations at the Kennedy Space Center in preparation for the Shuttle orbital flight test activity.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding will provide for the maintenance of technical facilities and equipment, chemical cleaning, engineering design, technical documentation and analyses, telecommunications, component fabrication, photographic support and logistics support.

Examples of specific services to be provided in FY 1980 include: (1) operation and maintenance of specialized electrical and cryogenic systems, and maintenance of test area cranes; (2) operation of shops to do metal furbishing, anodizing, plating, stripping, and etching of selected items of in-house fabricated flight hardware; (3) cleaning of hoses, gauges, tubing, and related flight items that are fabricated in-house; (4) engineering, installation, operation and maintenance of closed circuit fixed and mobile television required for support and/or surveillance of tests; (5) photographic services including still and motion picture processing and audio visual mission support; (6) fabrication of models, breadboards, and selected items of flight hardware; (7) technical documentation services, telecommunications, and graphics; (8) technical services in support of Center operations including receipt, storage and issue of research and development supplies and equipment, and transportation services; and (9) management services in support of Center operations, including data management, microfilming and preparation of technical documentation.

FY 1980 funds will also provide a basic level of maintenance, operation, and support services required at the White Sands Test Facility to support program requirements including material and component testing, and Shuttle orbital maneuvering systems test support.

In addition, FY 1980 funds will provide the basic level of support to the National Space Technology Laboratories for the static test firing and integrated component testing of the Space Shuttle main engine and the qualification of the main propulsion system.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Launch Systems Support	37,538	34,900	33,800	44,200

OBJECTIVES AND STATUS:

Launch Systems Support provides for the development and test of the checkout and launch facilities and associated ground support equipment, as well as the technical services required to support the test, checkout and launch of the Space Shuttle and payloads for the development test flights at the Kennedy Space Center.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

FY 1979 Launch Systems Support funding was decreased by $1.1 million to meet additional requirements for KSC facility operations support in preparation for the Shuttle orbital flight test effort.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 launch systems support requirements at the Kennedy Space Center are for the continuing preparation of the launch facilities to accommodate the Shuttle orbital flight test missions.

FY 1980 activities will support the integration and checkout of the space vehicle and its payloads and ground support systems to accommodate the Space Shuttle flight hardware and payload systems.

FY 1980 funding requirements provide for mechanical ground system activities involving operation and maintenance of launch systems and facilities for the Shuttle; support for development testing of the Kennedy Space Center-designed Shuttle equipment in the launch equipment test facility; maintenance and operation of the Kennedy Space Center electrical and mechanical utilities systems; and operation of technical shops and the precision cleaning laboratory which supports maintenance activities.

FY 1980 funding will also support the electrical/electronic and launch instrumentation systems, such as automated checkout equipment, operational voice and TV communications, computations, measurements, and telemetry. These activities include operations and maintenance support of communication, computational and instrumentation systems for the Shuttle, and instrumentation and measurement support for development testing of the Kennedy Space Center-designed Shuttle equipment in the launch equipment test facility.

BASIS FOR FY 1980 FUNDING REQUIREMENTS:

ADVANCED PROGRAMS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Advanced Programs	10,000	5,000	7,000	13,000

OBJECTIVES AND STATUS:

The Advanced Programs objective is to provide technical as well as programmatic data for the definition and evaluation of potential future space programs and systems. These efforts have continuously provided the basis for new programs and systems, such as the Apollo, Skylab, and the Space Shuttle. In support of these activities, subsystem studies and supporting development activities are conducted to demonstrate significant performance and reliability improvements and to reduce future program risks and development costs through the effective use of new technologies.

In FY 1979, studies include use of the Space Shuttle for fabrication and erection of space structures and in-orbit construction techniques, and definition of a manned orbital transfer vehicle including crew module and propulsion module for geosynchronous mission operations. Definition of a 25-KW power system will be initiated in FY 1979.

CHANGES FROM FY 1979 ESTIMATE:

Congressional authorization and appropriation action on the FY 1979 budget request increased the funding by $2.0 million for the 25-KW power system efforts.

BASIS OF FY 1980 ESTIMATE:

In FY 1980 major emphasis will be placed on studies and definition of near-term mission options that are possible because of the operational capability and flexibility of the space transportation system. This includes orbital operations associated with the fabrication, deployment and operation of advanced space systems using space structures and space power systems, retrieval and reuse of space systems, long duration operations in low earth orbit, and systems to allow operational capabilities at geosynchronous orbit.

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Advanced studies planned in FY 1980 include (a) continued definition of a manned orbital transfer vehicle including crew module and propulsion module for geosynchronous mission operations, (b) continued definition of space structures erection and construction in orbit techniques, and (c) definition of potential future power system requirements.

FY 1980 funding will also provide for the continued definition of a 25-KW power system and related evaluation efforts. The 25-KW power system would provide the capability for extended duration on-orbit operations and electrical power sources for payloads requiring additional power for longer periods of time than the Shuttle can accommodate alone. The 25-KW power system would be functionally, mechanically, and electrically compatible with the Shuttle orbiter interfaces. The power system would remain on-orbit in a stable, quiescent mode when not being utilized to support a space transportation mission or a free-flying spacecraft. It would be retrieved and returned to Earth in the cargo bay of the Shuttle for refurbishment or major repair.

In addition, FY 1980 funding is required for the definition of the solar electric propulsion stage (SEPS). The SEPS is a low-thrust, long-duration space propulsion system which would extend the Shuttle/IUS performance capability and permit a variety of additional high energy missions to be achieved. In addition to its role in automated high energy transportation, it could be used for mission support functions such as on-orbit servicing, orbit debris control and payload positioning and could provide a SEPS-based orbital test facility supporting technology demonstration of various space subsystems.

Subsystems studies and supporting development efforts will be conducted in support of these studies. The main objective is to evaluate technical feasibility in the critical areas involved.

SPACE TRANSPORTATION SYSTEM OPERATIONS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Shuttle operations	14,800	21,200	21,200	114,600	2-23
Payload support operations	1,700	12,200	12,200	38,500	2-24
Total	16,500	33,400	33,400	153,100	

OBJECTIVES AND STATUS:

Space Transportation System Operations will provide the transportation services and operational activites to bring about a new era in capitalizing on the unique advantages of space to expand human knowledge and increase the practical benefits here on Earth. Space Transportation System Operations will provide for the delivery of free flying payloads to low Earth orbit, conduct of experiments using the Shuttle orbiter as a carrier vehicle, conduct of experiments in the Spacelab, conduct of experiments using Spacelab pallets, delivery of payloads to synchronous and other high energy orbits using the combined capabilities of the Shuttle and upper stages, retrieval of free flying payloads from low Earth orbit, and on-orbit servicing of satellites. Operational flight missions will be planned and conducted to accomplish these activities in an efficient and economical manner by appropriate combination of payloads, experiments and mission objectives on specific flights. The Space Transportation System Operations activites integrate the Space Shuttle system, the Spacelab, and the upper stages into a versatile and economical system; accomplish mission planning; provide the recurring hardware and consumables; and support all launch, flight recovery, crew and related activities.

BASIS OF FY 1980 ESTIMATE:

Space Transportation System Operations funding in FY 1980 is required to support early NASA missions in 1981, 1982, and 1983. Activities include the continued procurement, assembly, and checkout of solid rocket booster, external tank, and upper stage flight hardware, as well as the development of flight operations plans and procedures for the Space Shuttle and payload support activities.

Shuttle Operations - Space Shuttle flight hardware components include the external tank and solid rocket boosters. External tank components will be delivered to the Michoud Assembly Facility in Louisiana and will be used to fabricate and assemble the liquid oxygen and liquid hydrogen propellant tanks. After final testing, the external tank will be shipped by barge to the Kennedy Space Center in Florida. The solid rocket

booster electronic and instrumentation parts, thrust vector control components, recovery systems, attach structures, forward and aft skirts, separation motors, and solid rocket motors will be shipped to the Kennedy Space Center where final assembly and checkout will be performed prior to flight. FY 1980 funding is also required for the development of standardized orbiter avionics software programs, mission plans and trajectory analyses, crew training and procedures documentation, and payload-to-orbiter integration analyses. Detailed plans and procedures for missions to be flown in 1981 will be developed to reflect the unique mission profiles, structural load requirements and crew activities for each mission.

Payload Support Operations - FY 1980 payload support funding is required for the procurement of unique payload related hardware and services. Included are the upper stages which are required to provide the capability to deploy Shuttle-launched payloads to orbits not attainable by the Shuttle alone; unique mission analyses such as spacecraft-to-upper stage analytical integration, special environment analyses required for unique payloads, and trajectory support for nonstandard orbits; maintenance and refurbishment of multi-use reusable mission related flight equipment; and flight operations planning for early Spacelab missions. FY 1980 funding includes the continued procurement and assembly of inertial and spinning solid upper stages, and analytical integration and special mission planning activities for payloads such as Galileo, International Solar Polar, Space Telescope, Solar Maximum Mission, Tracking and Data Relay Satellite System, and Active Magnetospheric Particle Tracer Experiment.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRANSPORTATION SYSTEMS — EXPENDABLE LAUNCH VEHICLES PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Scout	16,342	16,400	11,400	7,300	3-2
Centaur	41,458	21,500	21,500	18,300	3-4
Delta	70,400	38,600	38,600	43,100	3-5
Atlas-F	6,300	---	---	2,000	3-6
Total	134,500	76,500	71,500	70,700	
Distribution of Program Amount by Installation:					
Kennedy Space Center	11,235	7,800	9,660	3,800	
Goddard Space Flight Center	64,618	34,500	33,685	40,400	
Langley Research Center	16,100	16,300	11,340	7,200	
Lewis Research Center	38,203	16,700	15,822	16,400	
Headquarters	4,344	1,200	993	2,900	
Total	134,500	76,500	71,500	70,700	

OFFICE OF SPACE TRANSPORTATION SYSTEMS — EXPENDABLE LAUNCH VEHICLES PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the expendable launch vehicles program is to provide for the centralized procurement of launch vehicles and launch support services for NASA's automated spacecraft missions. The program includes the procurement of launch vehicle hardware, launch services, engineering and maintenance, and, as required, development of improved vehicle systems, including the necessary ground support equipment. Launch vehicles currently being procured are: Scout, Centaur, Delta, and Atlas-F.

The expendable launch vehicles program includes funding for vehicle hardware, such as solid rocket motors, boosters, upper stages, shrouds, adapters, mission-unique hardware, and launch support including preparation of hardware for launch, guidance and control services, mission software, prelaunch and postlaunch engineering analysis, transportation, propellants, and range support. It also includes procurement of vehicle hardware to be used as back-up support for early users transitioning to the Space Transportation System.

Launches under this program are conducted from sites located at the Eastern Test Range in Florida, the Western Test Range in California, the Wallops Flight Center in Virginia, and the San Marco platform off the coast of Kenya, Africa.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

Congressional appropriation action on the FY 1979 budget request reduced the funding by $5.0 million.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

SCOUT

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Scout	16,342	16,400	11,400	7,300

OBJECTIVES AND STATUS:

The Scout launch vehicle was initiated by NASA in 1959 with the goal of economically launching a wide variety of small scientific satellites, space probes, and re-entry experiments. The first Scout launch occurred in July 1960. In the ensuing 18 years, there have been 98 launches, and 84 of these launches have been successful.

The Scout vehicle is the smallest launch vehicle employed by NASA. It is a four-stage, solid propellant launch vehicle. The vehicle is approximately 22.4 meters in length (73 feet) and the first stage booster has a diameter of 1.14 meters (3.75 feet). It is capable of placing a 180 kilogram (400 pound) payload in a 556 kilometer (300 nautical mile) orbit.

The Langley Research Center, located at Hampton, Virginia, has managed the Scout project since its inception. The prime contractor for the production, checkout, and launch of Scout is the Ling-Temco-Vought Aerospace Corporation, located in Dallas, Texas. Scout vehicles are launched from the Western Test Range, California; from Wallops Island, Virginia; and from the San Marco platform off the African coast near Kenya.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The $5.0 million Congressional reduction in the Expendable Launch Vehicle budget was allocated to this project. The changes in FY 1979 consisted of rephasing the effort originally planned.

BASIS FOR FY 1980 ESTIMATES:

The funds required in FY 1980 will be used for engineering, technical support, vehicle testing and checkout, launch operations and maintenance of launch facilities and ground equipment. FY 1980 funds will provide for completion of launch service activity for the Magnetic Field Satellite to be launched from the Western Test Range. Preparation will be initiated for launching two San Marco cooperative missions in 1981 from the African San Marco launch platform.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

CENTAUR

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Centaur	41,458	21,500	21,500	18,300

OBJECTIVES AND STATUS:

This project provides for the procurement and launch of the Atlas booster stage and the Centaur upper stage. The Centaur is a high performance upper stage, which is the most powerful used by NASA for automated missions. It is being used with the Atlas booster for high energy missions, particularly planetary and synchronous orbits. The Atlas Centaur vehicle is 40 meters (131 feet) in length and has a diameter of 3.1 meters (10 feet).

In addition, the Centaur has been previously used with the Titan booster to launch heavier spacecraft beyond the capability of the Atlas Centaur. In this configuration, the Titan Centaur has successfully launched two Helios missions, two Viking missions, and two Voyager missions. Since NASA has no future plans to use the Titan Centaur vehicle combination, it has been phased out.

BASIS OF FY 1980 ESTIMATE:

Funds required in FY 1980 will provide for the post launch support of the HEAO-C mission planned to be launched in late FY 1979, for the procurement of Atlas Centaur vehicle hardware to provide backup support for users transitioning to the Space Transportation System, and for the phaseout of production capability at the prime contractor facilities. The last NASA mission using this vehicle system is HEAO-C. However, reimbursable launch support will be continued through CY 1981 in support of Intelsat and DOD missions. NASA's responsibilities for management and an orderly phaseout will be continued through this period.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

DELTA

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Delta	70,400	38,600	38,600	43,100

OBJECTIVES AND STATUS:

The Delta launch vehicle is the most widely used vehicle in NASA's expendable launch vehicle family. Since its first use in 1960, this vehicle has been utilized in 147 launches and has experienced a success record of over 91 percent. It is presently operational with two and three stage configurations and a multiburn second stage capability. The first stage is an elongated Thor booster with three, six, or nine strap-on solid motors for thrust augmentation.

The second stage Delta, which provides a multiple restart capability, uses an inertial guidance system for guiding the first stage booster and the second stage Delta. The third stage utilizes the Thiokol TE-364 solid motor, which is spin stablized. This vehicle, in its three-stage configuration, is approximately 35 meters in length (115 feet) and has a diameter of 2.44 meters (8 feet). It is capable of placing a 1,772 kilogram payload (3,900 pounds) into a 555 kilometer (300 nautical mile) orbit.

BASIS OF FY 1980 BUDGET ESTIMATE:

The FY 1980 funding will be used to continue the Delta launch vehicle procurements initiated in prior years to support NASA spacecraft requirements and to sustain a minimum production capability to back up early users scheduled on the Space Transportation System. Funds are also required for technical and engineering support to sustain vehicle test and checkout and launch operations, and to support maintenance of launch facilities and ground equipment.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

ATLAS-F

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Atlas-F	6,300	---	---	2,000

OBJECTIVES AND STATUS:

The Atlas-F is a one and one-half stage vehicle which uses liquid oxygen and kerosene as propellants. The vehicle is a refurbished surplus Intercontinental Ballistic Missile (ICBM) being managed by the USAF for space missions. NASA has used this vehicle to launch the TIROS-N and SEASAT missions, both of which were successfully launched during 1978.

BASIS FOR FY 1980 FUNDING REQUIREMENTS:

The $2 million required in FY 1980 will be used to modify the Atlas vehicle, including the fairing, and for the vehicle integration of the Search and Rescue missions. The Search and Rescue missions will be launched as piggy-back missions with National Oceanic and Atmospheric Administration satellites beginning in 1982.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE SCIENCE PROGRAMS

Programs	Budget Plan 1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Physics and astronomy	224,200	285,500	282,900	337,500
Planetary exploration	147,200	187,100	182,400	220,200
Life sciences	33,300	40,600	40,100	43,900
Total	404,700	513,200	505,400	601,600

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

PHYSICS AND ASTRONOMY PROGRAMS

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
High energy astronomy observatories development	19,811	11,400	11,100	4,800	4-7
Solar maximum mission development	29,600	16,200	16,200	600	4-8
Space telescope development	36,000	79,200	79,200	112,700	4-9
International solar polar mission development	---	13,000	13,000	50,000	4-11
Shuttle/Spacelab payload development	27,061	38,300	34,900	41,300	4-13
Explorer development	24,297	29,800	29,800	30,400	4-15
Mission operations and data analysis	19,298	23,300	25,000	36,500	4-17
Research and analysis	42,934	45,000	44,400	34,300	4-20
Suborbital programs	25,199	29,300	29,300	26,900	4-25
Total	224,200	285,500	282,900	337,500	
Distribution of Program Amount by Installation:					
Johnson Space Center	275	80	220	216	
Marshall Space Flight Center	85,394	115,114	125,138	158,112	
Goddard Space Flight Center	85,590	95,492	83,377	76,963	
Jet Propulsion Laboratory	9,583	26,624	27,212	58,353	
Wallops Flight Center	6,118	6,950	6,614	5,219	
Ames Research Center	15,477	13,013	7,238	4,157	
Langley Research Center	1,498	400	1,150	855	
Lewis Research Center	738	---	200	---	
Headquarters	19,527	27,827	31,751	33,625	
Total	224,200	285,500	282,900	337,500	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

OFFICE OF SPACE SCIENCE

PHYSICS AND ASTRONOMY PROGRAM

LAUNCH SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
High Energy Astronomy Observatories	HEAO-C	1979
Solar Maximum Mission	SMM	1979
Space Telescope	ST	1983
International Solar Polar Mission	ISPM	1983
Space Shuttle Orbital Flight Test Payloads	OFT	1980
Spacelab	Spacelab-1	1981
	-2	1982

(Shuttle/Spacelab Payloads will build to a flight rate of two dedicated missions per year in 1984)

Explorers:

Dynamics Explorer	1981
San Marco-D/Multistationary	1981
San Marco-D/Low Orbit	1981
Solar Mesophere Explorer	1981
Infrared Astronomical Satellite	1981
Cosmic Ray Isotope Experiment	1981

LAUNCH SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
	Active Magnetospheric Particle Tracer Explorer (AMPTE) Experiment	1982
	Cosmic Background Explorer	1984
	Extreme Ultraviolet Explorer	1984
Suborbital Programs:		
Sounding Rockets		About 60 launches per year
Balloon Flights		About 70 launches per year

OFFICE OF SPACE SCIENCE

PHYSICS AND ASTRONOMY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The major objective of the Physics and Astronomy program is to increase our knowledge and understanding of the Sun and the Earth's plasma environments; and of the origin, evolution, structure, and composition of the universe, including the Sun, other stars and celestial bodies. Under this program, research is being conducted to investigate the magnetosphere, the interplanetary medium, the Sun, the coupling that links these different plasma regions, and the processes that control them. Space-based investigations of cosmic ray, X-ray, gamma ray, ultraviolet, infrared, and radio emissions, not possible from ground-based observatories because of the obscuring effect of the Earth's atmosphere, give us a unique opportunity to study the Sun and other celestial bodies. The basic scientific research in the Physics and Astronomy program contributes to the knowledge necessary for the atmospheric research efforts in Space Applications. The investigations in Physics and Astronomy are the basis for increasing our knowledge of the fundamental laws of nature, especially those which control the environment of the Earth.

To achieve the objectives of the Physics and Astronomy program, NASA uses techniques ranging from theoretical and laboratory research through aircraft, balloon, and sounding rocket flights and then to small explorer spacecraft, automated observatories, and the Space Shuttle and Spacelab. Research teams involved in this program are located at NASA field centers, other government laboratories, universities, and industrial laboratories.

The scientific information obtained and the technology developed in the program are made available to the scientific and technical community for applications and the advancement of scientific knowledge, education and technology.

The Physics and Astronomy missions undertaken to date have been highly successful. Explorer satellites, a relatively low cost series of missions begun in 1958, have made a number of basic discoveries, including the discovery of the Earth's radiation belts, and have gone on to survey the Earth's near-space environment and to study its variation with space and time. They have also made major discoveries about celestial phenomena important to our understanding of the universe. The Explorers have contributed greatly to technology development and demonstration of precursor instruments that have flown later on observatories. The automated observatory missions to date include the first two missions of the High Energy Astronomy Observatory series, which were launched in August 1977 and November 1978. HEAO-1 has completed its mission and HEAO-2 is currently engaged in in significant high energy astrophysics investigations. Earlier observatories include the Orbiting Solar

Observatory series, the most recent of which (OSO-8) has just completed operations after three and one half years of acquiring data for solar and high energy astronomy investigations; and the Orbiting Astronomical Observatory series, the last of which (OAO-3) is in its seventh year of productive operations.

Major accomplishments during FY 1978 included the launch of the second observatory of the HEAO series, which will greatly expand our knowledge of the X-ray universe; the launches of the International Sun-Earth Explorers, which are improving our understanding of the dynamic interactions between the solar wind and the Earth's magnetosphere; the launch of the International Ultraviolet Explorer, which is obtaining high resolution data in the ultraviolet region of the spectra of stars and planets; and the commencement of development work on the most powerful astronomical instrument ever built--the Space Telescope, which will be launched on the Shuttle in 1983. The Space Telescope will be conducting research at the forefront of optical and ultraviolet astronomy during the final decades of this century. Major progress was also made in the development of the Solar Maximum Mission and several explorers, including the Dynamics Explorer and the Infrared Astronomical Satellite.

During FY 1979, work is continuing on the remaining mission of the High Energy Astronomy Observatory series (HEAO-C), which is scheduled for launch in 1979. This mission will study cosmic ray composition and initiate a limited survey of the gamma ray sky. Development efforts will be completed on the Solar Maximum Mission, which is planned for launch in 1979. Its primary objective is to conduct research on the physics of solar flares and solar transient events. Development efforts are continuing for the Space Telescope, experiments to be conducted on a Shuttle orbital flight test and Spacelabs 1 and 2, and instruments to be flown on follow-on Spacelab missions. Development work commenced in October 1978 for the International Solar Polar Mission to be launched in 1983. This mission will conduct exploration of the heliosphere, the space around the Sun, and obtain observations of the Sun over the full range of heliographic latitudes. Work is continuing on several explorers. The Dynamics Explorer to be launched in 1981 will investigate the interaction of the Earth's magnetosphere and ionosphere. The Infrared Astronomy Satellite, a cooperative mission with the Netherlands and the United Kingdom to be launched in 1981, will perform an infrared all-sky survey and study selected galactic and extragalactic sources. The San Marco-D mission is a cooperative program with Italy with two launches in 1981. A Cosmic Ray Isotope Experiment will be launched on a DOD satellite in 1981. Development work will commence in FY 1979 on the Solar Mesosphere Explorer, which will be launched in 1981. This mission will study solar ultraviolet flux and corresponding changes occurring in ozone and the related chemistry of the Earth's atmosphere as a result of variations in the incoming solar ultraviolet radiation during the solar maximum period. A number of explorer definition studies have been conducted, resulting in three future explorer missions: the Cosmic Background Explorer (COBE); Active Magnetospheric Particle Tracer Explorer (AMPTE); and the Extreme Ultraviolet Explorer (EUVE). COBE will carry out definitive measurements of the spectrum and directionality of the microwave background radiation believed to be a remnant of the "Big Bang" which began our present universe. AMPTE will study the solar wind at the subsolar point and identify particle entry windows, entry mechanisms, energization and transport processes into the magnetosphere. EUVE will survey the entire celestial sphere at wavelengths between 100 and 1,000 angstroms, providing our first extensive information on super-hot "dying" stars. Scientific progress is also being achieved from the Mission Operations and Data Analysis program, the Research and Analysis program and the Suborbital program.

FY 1980 funding will provide for the continued development and launch of major flight projects, including launch operations and data analysis associated with the Solar Maximum Mission planned for a late 1979 launch; continuation of the work on the Space Telescope leading to a Shuttle launch in 1983; and continued work on the International Solar Polar Mission leading to a Shuttle launch in 1983.

With FY 1980 funding, work will also continue on experiment hardware, integration requirements and mission operations plans for the payloads to be flown on a Shuttle orbital flight test and on the Spacelab 1 and 2 missions, as well as development of payloads to be flown on follow-on Spacelab missions. These payloads include experiments in the astronomy, astrophysics, solar physics, and space plasma physics disciplines. The FY 1980 funding for the Explorer program will provide for continued work on Solar Mesosphere Explorer development, the San Marco-D missions, and hardware and subsystems and experiment fabrication for the Dynamics Explorer and Infrared Astronomical Satellite missions. Work is planned on one or more of the three upcoming explorers (COBE, AMPTE, EUVE) during FY 1980.

FY 1980 Missions Operations and Data Analysis activities will focus on the operations of and analysis of data from satellites which are producing valuable scientific data. These satellites include the first two High Energy Astronomy Observatories, the third Orbiting Astronomy Observatory, a Small Astronomy Satellite, the International Ultraviolet Explorer, the International Sun-Earth Explorers and an Atmosphere Explorer. Mission Operations and Data Analysis will also be underway for the remaining High Energy Astronomy Observatory and the Solar Maximum Mission.

For Suborbital programs, FY 1980 funds will provide for continuation of sounding rocket activity, including near concurrent launching of several rocket payloads for coordinated observation and for correlation with satellite observations and the continued operation of the Kuiper Airborne Observatory, and continuing scientific investigation through balloon flights.

FY 1980 Research and Analysis funding will support a broad range of efforts to provide the research and technology base required for well-conceived and defined future programs. In our supporting research and technology program, tasks critical to maintaining a firm scientific base for Physics and Astronomy will continue. In the area of Spacelab Science Payload Definition, efforts will continue on detailed studies of specific instruments. The Data Analysis activity will include operations of the National Space Science Data Center (NSSDC) and the general data analysis activities.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

HIGH ENERGY ASTRONOMY OBSERVATORIES (HEAO) DEVELOPMENT

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
HEAO spacecraft	9,865	9,065	8,765	2,300
HEAO experiments	8,904	1,735	1,735	1,400
Ground operations	1,042	600	600	1,100
Total	19,811	11,400	11,100	4,800
Basic mission operations and data analysis	(3,545)	(5,000)	(5,000)	(5,351)
Extended mission operations and data analysis	(1,794)	(2,000)	(3,700)	(8,549)
Atlas/Centaur (expendable launch vehicle program)	(5,200)	(---)	(8,300)	(---)

OBJECTIVES AND STATUS:

A major scientific objective of the HEAO program is to observe and investigate not only those X-ray sources that are already known, but also a much larger number which, either because of their distance or their low intensity, remained undetected before the advent of HEAO.

A product of this work, already underway with HEAO-1 and 2, has been the discovery of new classes of weaker X-ray sources, as well as the observation of the stronger sources outside our galaxy. Other equally important objectives include the observation of rare species of cosmic rays, which are crucial to our understanding of heavy element formation, and the observation of the nuclear gamma ray lines, which are important in understanding the origin of the elements. This program promises to advance our understanding of newly discovered processes that release extraordinary amounts of energy. It will also enhance our understanding of the creation of matter, and it will deepen our knowledge of observed phenomena such as quasars, pulsars, novae and supernovae.

The HEAO program consists of three missions utilizing Atlas-Centaur launch vehicles launched from the Eastern Test Range. HEAO-1, an X-ray survey mission, was successfully launched in August 1977. HEAO-1 results (discussed more fully under Mission Operations and Data Analysis) include the discovery of over 1,000 X-ray sources, as well as an isotropic plasma of many million degrees temperature. HEAO-2 was successfully launched in November 1978, and carries a grazing incidence X-ray telescope to make detailed studies of specific X-ray sources. The third mission (HEAO-C), to be launched in 1979, will carry a combination of cosmic ray and gamma ray instruments.

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CHANGES FROM FY 1979 BUDGET ESTIMATE:

The FY 1979 estimate reflects a reduction in funding requirements for the HEAO-B spacecraft associated with the on-time, successful launch. These savings have been applied to extending HEAO-1 operations.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 funding requirements will provide for the initial orbital operations of HEAO-C, continuation of the Guest Investigator program, support of HEAO-2, and the costs associated with the completion of the HEAO prime contract.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

SOLAR MAXIMUM MISSION (SMM) DEVELOPMENT

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	17,600	8,600	8,600	---
Experiments	11,800	7,100	7,100	---
Ground operations	200	500	500	600
Total	29,600	16,200	16,200	600
Delta (expendable launch vehicles program)	(1,200)	(---)	(---)	(---)

OBJECTIVES AND STATUS:

The major objective of the Solar Maximum Mission (SMM) is to conduct detailed studies of the solar flare processes and the associated solar active regions during the next period of peak solar activity, which will occur in 1979 through 1981. The investigations will be conducted over a broad spectral range with high spectral, spatial and time resolution, and with the objective of explaining the underlying physical mechanisms and complex energy transfer and high energy particle acceleration processes involved.

To achieve the scientific objective, SMM will be launched near the period of maximum solar activity in order to observe a sufficient number of large and small flare events. Statistics, based on records of the past 19 solar cycles, show that a launch in late 1979 will assure that the spacecraft will be operating during the

period of high solar activity. The study of flares is currently considered to be one of the most timely and important in the NASA solar physics programs, both by virtue of the significance of the phenomenon and by the state of readiness of the technology required to capitalize on the phenomenon. A great deal has already been learned about the flare process through instruments flown on OSO and Skylab. The SMM will be the first to make simultaneous observations over the necessary broad range of wavelengths.

In the area of solar terrestrial relationships, indications of a link between some form of solar activity (radiation, particles, and magnetic fields) and the Earth's weather and climate are increasing. With the basic capabilities of the flare payload, the inclusion of solar constant instrumentation, and the complementary International Sun-Earth Explorer research, the Solar Maximum Mission will make a significant contribution to our understanding of the effects of solar phenomena.

The procurement, assembly, and test of the experiments and spacecraft subsystems for SMM were basically completed in FY 1978. During FY 1979, the experiments and the spacecraft will be integrated. The observatory system will be tested, calibrated, and prepared for launch. The mission operations teams will be trained, and the guest investigator teams will be formed.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding will provide for launch and the initial mission operations of the SMM observatory, for the work of the science experimenter teams, and for the initial data analysis.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

SPACE TELESCOPE (ST) DEVELOPMENT

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Spacecraft	26,200	54,800	54,800	82,500
Experiments	9,800	24,400	24,400	30,200
Total	36,000	79,200	79,200	112,700
Space transportation system operations	(100)	(200)	(200)	(100)

OBJECTIVES AND STATUS:

The Space Telescope will make a major contribution to understanding the origin, evolution and scale of the universe; understanding the stars and galaxies, and the nature and behavior of the gas and dust between them; and developing a physical understanding of the universe. Operating in space above the atmospheric veil surrounding the Earth, the Space Telescope will increase by several hundredfold the volume of space accessible for observations. With its significant improvements in resolution and precision, in light sensitivity and in wavelength coverage, the Space Telescope will permit scientists to investigate fundamental questions concerning the structure, the origin, the evolution, and the energy balance in the universe; these investigations could never be carried out using ground-based observatories due to the obscuring and distorting effects of the Earth's atmosphere. Its capabilities will open up to the astronomical sciences, and to science in the broadest sense, a road to new knowledge which will help shape our concept of the universe.

The Space Telescope will enable astronomers to study radiations in the visible and ultraviolet regions of the spectrum. It will be more sensitive than ground-based telescopes and will record greater detail about the objects under study. It will make possible observations of objects so remote that the light will have taken many billions of years to reach us. As a result, we will be able to look far into the distant past of our universe. It will also contribute significantly to the study of the early stages of stars and the formation of solar systems; to the observation of such highly evolved objects as supernova remnants and white dwarf stars; and to other studies related to the origin and physical extent of the universe. With the Space Telescope, we may be able to determine the nature of quasars, and the processes by which they emit such enormous amount of energy. It will also be possible to study individual stars in nearby galaxies and perhaps to determine if nearby stars have planetary systems.

The Space Telescope will be an automated observatory, delivered into orbit in 1983 by the Space Shuttle. Data from its science instruments will be transmitted to Earth via the Tracking and Data Relay Satellite System. The ST will differ from existing automated satellites in that its design will permit in-orbit maintenance, repair, and retrieval by the Space Shuttle for return to Earth, refurbishment and reuse.

During FY 1978, design and development efforts were initiated. Contracts were awarded for the Optical Telescope Assembly and the Support Systems Module. During FY 1978, the contractors completed their planning, started preliminary design and initiated long-lead procurements. One of the most significant procurements was for two 2.4 meter diameter primary mirror blanks for the Optical Telescope Assembly. The contractors also completed negotiations with their major subcontractors for the focal plane structure, truss assembly, baffles, main ring, and the pointing control system. Project Requirements Reviews (by the observatory contractors) were conducted in February 1978. The Support Systems Module contractor is also actively involved with performing analyses necessary to ensure a totally integrated system. Scientific instrument contractors completed their planning and definition, conducted Project Requirements Reviews and initiated preliminary designs of instruments. Instrument development teams participated in the design of the instruments.

FY 1979 activities support continued progress in the Space Telescope design and development. The first primary mirror blank has been fabricated and shipped to the Optical Telescope Assembly contractor for grinding and polishing. Polishing of the mirror, which will be performed by a new computer-controlled polishing machine, is being demonstrated by polishing a 60-inch mirror to ST specifications. Polishing of the flight primary mirror is scheduled to begin in August 1979. A backup to the flight primary mirror will be fabricated and delivered in April 1979, for polishing, using traditional manually-controlled polishing machines. The observatory contractors will complete their preliminary designs leading to Preliminary Design Reviews in the last half of FY 1979. Detailed designs will be initiated following these reviews. The Preliminary Design Reviews for the Science Instruments will be conducted in early FY 1979, after which the payload selection will be confirmed and detailed instrument designs initiated. In addition, a contract will be awarded for the development of the command and data handling system for the scientific instruments, and for the preparation of the verification and acceptance activities associated with the instruments.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 funding requirements will support detailed design and development of the Optical Telescope Assembly, the Support Systems Module, and Science Instruments. The Critical Design Reviews for these elements are scheduled for completion by mid-1980. After these reviews, fabrication and assembly activities will begin. Early in FY 1980, thermal/structural simulators of all the Science Instruments are scheduled to be delivered to Goddard Space Flight Center for development testing, using an early model of the focal plane structure provided by the Optical Telescope Assembly contractor. Final design and preliminary coding of flight software for the Systems Support Module will be completed in FY 1980.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

INTERNATIONAL SOLAR POLAR MISSION (ISPM) DEVELOPMENT

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	---	9,700	3,700	35,000
Experiments	---	3,100	9,200	14,000
Ground operations	---	200	100	1,000
Total	---	13,000	13,000	50,000
Space transportation systems operations	(---)	(100)	(100)	(6,700)

OBJECTIVES AND STATUS:

The International Solar Polar Mission is a joint NASA and European Space Agency mission designed to obtain the first view of the solar system from a new perspective -- a view from far above and far below the plane in which the planets orbit the Sun's equator. The two spacecraft will aid in the study of the relationship between the Sun and its magnetic field and particle emissions (solar wind and cosmic rays) as a function of solar latitude, in order to gain insight into the possible effects of solar activity on the Earth's weather and climate.

The objective of the International Solar Polar Mission is to conduct an exploration of those regions of the heliosphere above and below the equatorial plane of the Sun. Observations in the extreme, high latitude regions of the Sun have not been made before, and evidence indicates that this region of space is greatly different from the region in which the Earth is located. Based on the growing evidence of a link between solar activity and terrestrial weather and climate, the need to understand the processes that might result from such a link becomes more pressing. The characteristics of the solar wind vary with the solar cycle, and the variability is becoming progressively better known as a result of continuing space exploration. The high latitude features on the Sun are believed to affect the solar wind conditions at Earth. The Solar Maximum Mission and the International Sun-Earth Explorers will study the solar process from essentially the solar equatorial plane.

An intensive study of the Sun-wind interface is now required in order to better understand the relationship of the solar cycle activity and solar wind conditions at the Earth. The International Solar Polar Mission, which will offer the first direct look at the third dimension of the Sun, will play a significant role in such a study. The eventual goal is to identify and to understand the influence of the Sun and solar activity on the space surrounding the Earth and, in turn, the influence of the Sun on the Earth and the other planets.

NASA and the European Space Agency will each provide one spacecraft of approximately equal and complementary capabilities. Science experiments have been assigned to each of the two spacecraft by a joint selection committee. Launch, tracking and data acquisition, and mission operations will be carried out by NASA, with European Space Agency (ESA) participation.

Employing a concept that exploits the gravitational pull of Jupiter, the launch of the mission is planned for February 1983. Both the NASA and ESA spacecraft will be launched from a single Shuttle/Inertial Upper Stage vehicle on a trajectory to Jupiter. The gravitational force of Jupiter will be used to swing the two spacecraft on mirror image courses (north and south) back over the Sun, well above the solar equatorial plane. Both spacecraft will then pass over the north and south poles of the Sun.

During FY 1979, the tentatively selected experimenters will be confirmed, flight instrument design will begin and interface specifications will be established, and the spacecraft system contractor will be selected.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The FY 1979 funding requirements for the ISPM project development remain the same as the budget estimate. The redistribution between the spacecraft and the science project elements is based on receipt and review of the experiment proposals and is consistent with scheduling of the overall project milestones.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funds will provide for continued development of experiment hardware and the initiation of a contract to industry for the spacecraft system. Activities in the spacecraft contract are expected to include detailed system design, subsystem contracts, and electronic parts procurement.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

SHUTTLE/SPACELAB SCIENCE PAYLOAD DEVELOPMENT

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Science and equipment development	19,361	27,800	21,100	29,900
Integration and operations	7,700	10,500	13,800	11,400
Total	27,061	38,300	34,900	41,300
Space transportation systems operations	(---)	(7,900)	(7,900)	(20,100)

OBJECTIVES AND STATUS:

The objective of the Shuttle/Spacelab Science Payload Development program is to advance scientific research in the major disciplines of astrophysics, solar physics, space plasma physics, and astronomy by capitalizing on the unique capabilities of the Space Shuttle and Spacelab. The science payload development activities will provide for the design, development, and integration of experiments and special supporting subsystems to be flown on Shuttle orbital flight test and Spacelab missions. The efforts will also include provision for payload mission operations and data analysis.

Shuttle Orbital Flight Test (OFT) and Spacelab 1 and 2 Payload Development

Development activities for the experimental payloads to be flown on a Shuttle orbital flight test are proceeding well. All the instrument Critical Design Reviews have been completed and flight hardware is in

fabrication. The design of instrument support systems will be completed in early 1979. Spacelab 1, a joint undertaking by NASA and the European Space Agency, is planned for launch in late 1981, followed by Spacelab 2 in 1982. The primary objective of the first mission is the verification of the Spacelab performance and capabilities. The secondary objective is to obtain scientific, applications, and technology data. For Spacelab 1, a total of 42 (17 NASA and 25 ESA) investigations were selected for definition studies in early 1977, and for Spacelab 2, thirteen investigations were selected in mid-1977, for definition studies. The definition studies have provided a deeper technical and programmatic understanding of the individual investigations and of the system function of the entire complement of instruments. After completion of the definition studies in 1978, an assessment of the capabilities of the experiments and a confirmation for flight were made.

The Payload Specialist training for Spacelab 1 began in August 1978, and the specialists have been actively involved with the project for the last several months. Initial design evaluations of the Spacelab 2 instruments have been completed and several of the instruments have now commenced fabrication. Initial design evaluation of the mission-unique equipment has also been completed. Payload specialists for Spacelab 2 have been selected.

Shuttle/Spacelab Principal Investigator and Multiuser Payloads

Payloads to be flown on the Shuttle and Spacelab are divided in two classes: Principal Investigator (PI Class) Instruments, and Multiuser (MUI Class) Instruments. PI Class Instruments are instruments that are proposed for a specific scientific investigation by a single investigator who may have co-investigators. MUI instruments have a broad scientific capability, can accommodate a number of PI-furnished focal plane or ancillary instruments, and have a large user community. In general, PI Class and MUI Class instruments will fly together, making scientifically focused payloads. An Announcement of Opportunity was issued in 1978, soliciting proposals for investigations to be conducted on post Spacelab 3 missions. In response to the Announcement of Opportunity, approximately 200 proposals were received and will be evaluated in early 1979. The selection of PI experiments will be made in the spring of 1979, and development of the instruments will begin in late FY 1979.

During FY 1979 work will proceed on development of the solar optical telescope and the chemical release module. The solar optical telescope will allow high resolution observations of the solar surface features using a number of focal plane instruments. The system will be designed for changes of focal plane instrumentation between successive flights. The chemical release module will be used to trace the atmospheric motions of neutral constituents, to map out magnetic and electric fields, to display plasma instabilities and to study, using test particles, particle behavior. The Shuttle Infrared Telescope Facility, the subject of conceptual studies, will be designed to perform high resolution studies of star formations and other astronomical features utilizing six focal plane instruments. It will employ super-cooled structure and detector systems to study infrared sources and phenomena invisible to other ground-based and spaceborne systems.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease of $3.4 million in the FY 1979 estimate is the result of the Congress' general reduction in NASA's R&D appropriation, and the rephasing of funding requirements consistent with the delay in planned Spacelab missions. To prepare for the initial Principal Investigator and multiuser flights, the FY 1979 funding for integration was increased to establish the integration capability.

BASIS OF FY 1980 ESTIMATE:

Shuttle Orbital Flight Test (OFT) and Spacelab 1 and 2 Science Payload Development

During FY 1980, OFT science instrumentation will be completed and integrated. Test and final evaluation of the instruments will be undertaken. The science mission design and mission software activities will continue, leading to a late 1980 flight. The Spacelab 1 and 2 instruments will continue in fabrication and test. Software and mission design activities will also continue.

Shuttle/Spacelab Principal Investigator and Multiuser Payloads

FY 1980 funding will provide for continued development of the selected Principal Investigator instruments and the mission-unique activities necessary for the first multidisciplinary flight in 1982. The FY 1980 funding will also continue the development of the Solar Optical Telescope and the Chemical Release Module. During FY 1980, system studies will be completed for the Shuttle Infrared Telescope Facility to prepare for development beginning in FY 1981.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

EXPLORER DEVELOPMENT

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
International sun-earth explorers (ISEE)	3,021	---	---	---
Dynamics explorer (DE)	5,300	12,800	13,800	11,100
Solar mesosphere explorer (SME)	1,419	5,000	2,100	6,900
International ultraviolet explorer (IUE)	807	---	---	----
Infrared astronomical satellite (IRAS)	11,500	10,500	10,200	5,700
Other explorers	2,250	1,500	3,700	6,700
Total	24,297	29,800	29,800	30,400

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Mission operations and data analysis	(10,703)	(12,200)	(12,200)	(13,000)
Scout and delta (expendable launch vehicles program)	(11,400)	(3,500)	(9,200)	(---)
Space transportation system operations	(---)	(---)	(---)	(3,700)

OBJECTIVES AND STATUS:

The Explorer program, comprised of a number of individual projects, provides the principal means of conducting astronomical studies and long-term investigations of solar physics and of the near-Earth interplanetary environment which do not require observatories.

Included in the present program are missions to study atmospheric and magnetospheric physics; the several magnetospheric boundaries; interplanetary phenomena; and X-ray, ultraviolet, and infrared astronomy.

Studies are conducted to define future high priority science Explorer missions. NASA engages in cooperative missions with other U.S. Government agencies and other nations whenever such cooperation will assist in achieving NASA objectives. The Explorer program supports both the Solar Terrestrial and Astrophysics programs.

Solar Terrestrial and Atmospheric Explorers provide the means for conducting studies of the Earth's near-space environment. The program requires a wide variety of satellites in orbits extending from the very lowest reaches of the upper atmosphere, to the interplanetary medium beyond the Earth's magnetosphere. The Solar Terrestrial program is in a transition from the early discovery and mapping phase conducted over the past decade to a phase in which specific problems will be investigated in more depth. For example, the cause and effect interactions of the fluctuating solar wind on the Earth's environment are being studied by means of simultaneous measurements at different locations by projects such as the International Sun-Earth Explorers (ISEE), a cooperative effort with the European Space Agency. The ISEE A and B spacecraft were successfully launched in October 1977. ISEE C was successfully launched in 1978 and placed in a halo orbit between the Sun and Earth on November 20.

More efforts underway include development activity for the Solar Mesosphere Explorer, the Dynamics Explorer, and the San Marco-D missions, the latter a cooperative program with Italy. The Solar Mesosphere Explorer will be designed to investigate the stability of the Earth's ozone layer with emphasis on determining the response of ozone to changes in the solar ultraviolet flux. Definition studies for several missions are underway, including the Active Magnetospheric Particle Tracer Explorer (AMPTE), a cooperative program with the Federal Republic of Germany, with development activity anticipated in FY 1980 or FY 1981.

Astrophysics Explorers provide the means for carrying out astronomical studies which do not require large, complex observatories. Included in the program are the International Ultraviolet Explorer, which is a cooperative effort with the United Kingdom and the European Space Agency; and the Infrared Astronomical Satellite, a cooperative program with the Netherlands and the United Kingdom. The International Ultraviolet Explorer mission was successfully launched in January 1978. Astrophysics Explorers have been instrumental in initiating comprehensive astronomical studies in the X-ray, gamma ray and low frequency radio regions of the electromagnetic spectrum. Major efforts underway include continuation of hardware and subsystems procurement and experiment fabrication for the Infrared Astronomy Satellite; continuation of development work for the Cosmic Ray Isotope Experiment (CRIE), a cooperative program with DOD in which NASA will provide a scientific instrument for flight on an Air Force spacecraft; and future mission definition studies including the Cosmic Background Explorer (COBE) and the Extreme Ultraviolet Explorer (EUVE) with development to be initiated in FY 1980 or FY 1981.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The current estimate for the total Explorer program remains the same as the FY 1979 budget estimate. The redistribution of funds within the Explorer program reflects the revised schedule for the SME which permitted increased development activity on the Dynamics Explorer project and definition effort on other Explorers during FY 1979.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding will provide for continuation of hardware and subsystem procurement and experiment fabrication for the Infrared Astronomy Satellite Explorer, the Dynamics Explorer and the Solar Mesosphere Explorer; initial development activity for one or more of the Explorers - AMPTE, COBE, EUVE; continuation of work on CRIE and the San Marco-D mission; and definition studies for future Explorer missions.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

MISSION OPERATIONS AND DATA ANALYSIS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
High energy astronomy observatory (HEAO)	5,339	7,000	8,700	13,900
Solar maximum mission (SMM)	---	---	---	4,900
Space telescope (ST)	---	---	---	1,800
Orbiting explorers	10,703	12,200	12,200	13,000
Orbiting astronomical observatory (OAO)	1,956	2,600	2,600	2,900
Orbiting solar observatory (OSO)	1,300	1,500	1,500	---
Total	19,298	23,300	25,000	36,500

OBJECTIVES AND STATUS:

The purpose of this effort is to conduct operations and to analyze data from the Physics and Astronomy satellites after launch. Since a number of spacecraft have survived beyond their originally planned lifetimes, operations are continued for specific investigations that have high scientific potential.

In-orbit operations and data analysis activities in support of HEAO-1 and HEAO-2, launched in August 1977 and November 1978, respectively, are underway. HEAO-1 has completed nearly 18 months of successful operation. One of the major results obtained from HEAO-1 has been the discovery of a very thin, hot, plasma that appears to extend throughout the universe. This plasma may contain enough mass to close the universe, which implies an eventual contraction of the universe followed by a repeat "Big Bang" beginning. Precise celestial positions for about 100 X-ray sources have been determined, leading to new identification of the optical counterparts of these sources. The X-ray sky survey experiment on HEAO-1 has completed 2 1/2 complete scans of the sky for new X-ray sources. About 1/6 of the data have been reduced and indicate that the detection of well over 1,000 new X-ray sources will be achieved. The HEAO-1 data contains such a wealth of information that continued analysis for several years will be required to extract all of the scientific knowledge contained therein. HEAO-2 is presently undergoing on-orbit instrument checkout. All systems are performing excellently and we have every expectation that HEAO-2 will also make major scientific contributions. The Solar Maximum Mission will be launched in late 1979 with mission operations beginning in FY 1980.

Although the primary thrust of the Mission Operations and Data Analysis program involves operational satellites already in orbit, the Space Telescope program presents several unique features which must be provided for well in advance of launch. The Space Telescope is designed for operation for more than a decade, based on in-orbit maintenance, recovery, refurbishment, and relaunch and in-orbit changeout of the focal plane scientific instruments. During the operational period, it will be used the majority of the time by general observers scheduled on the basis of proposals submitted in response to periodic solicitations. Observing schedules will integrate these requirements with those of investigators who are involved with development of focal plane instruments. NASA has determined that the most efficient and scientifically satisfactory approach to science operations will involve establishment of an independent Science Institute which will operate under a long-term contract with NASA. While NASA will retain operational responsibilities for the observatory, the Institute will implement NASA policies in the areas of planning and management and scheduling of the scientific operations of the telescope.

A number of Explorer class spacecraft remain operational and continue to provide valuable and interesting scientific data. Analysis of these data have led to a number of significant new findings. For example, astronomers using the International Ultraviolet Explorer have discovered acetylene in the atmosphere of Saturn. This compound is an important starting material in the synthesis of many organic compounds. The IUE has also provided data which indicate that stars much cooler than our Sun possess solar-type winds which are so intense that a normal corona cannot develop. Further studies of these enhanced stellar winds should provide a better

understanding of the solar phenomenon itself. Mass flow on very large scales has also been observed in several X-ray binary systems. Large amounts of mass have been detected flowing from the normal type stars in these systems toward the neutron or black hole components. The Small Astronomy Satellite (SAS-3) has recently detected X-rays from two quasars (one of these objects is the closest quasar ever discovered). These observations add quasars to the growing list of energetic X-ray sources in the sky. Finally, the Atmospheric Explorer (AE) has provided valuable data which have aided in the understanding of the forces contributing to the re-entry of Skylab.

OAO-3 (Copernicus), which was launched in 1972, is providing a three-axis stabilized automated facility for observing celestial objects and interstellar material in the X-ray and ultraviolet spectral ranges. OAO-3 is the only currently operating or planned satellite capable of making spectroscopic observations in the important 900-1,150 angstrom wavelength region. During the past six years, new techniques have been developed which have enhanced the usefulness of OAO-3 by allowing the observation of objects six times fainter than could be observed when the satellite was first launched. As a result, many new classes of objects can now be studied by this observatory. FY 1979 funds support the operation of OAO-3 and the analysis of data obtained. Support is also being provided for guest investigators from universities, government institutions and several foreign countries. The program has involved over 160 investigators and 170 different scientific projects.

The operation of OSO-8 was terminated on September 30, 1978, after 3 1/2 years of successful operations, and FY 1979 will be the final year of data analysis for this mission. Major accomplishments in solar physics concern refined temperature models of the Sun's atmosphere from the temperature minimum up through the chromosphere, detection of impulsive brightenings in the transition zone that may represent the smallest extreme of flare processes, and detailed investigation of the heating of the lower chromosphere by short period waves. The stellar high energy experiments measured for the first time polarization in Cygnus X-2, indicative of a magnetic field, and the crystal spectrometers found spectral lines from ions in Cygnus X-3. The interstellar gas photometer was used to make a detailed model of the interstellar neutral gas (hydrogen and helium) that is streaming through our solar system. A symposium will be held in July 1979, at the Goddard Space Flight Center, to summarize the results of OSO-8. The accomplishments of OSO-8 have brought the Physics and Astronomy program a considerable distance toward the objective of understanding the intricate functions of the Sun in the Solar Terrestrial relationship.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The FY 1979 change reflects an increase of $1.7 million in the mission operations and data analysis phase of the HEAO program in order to extend the operations of the highly successful HEAO-1 mission.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funds will provide support for the continued operation of the HEAO-2 mission and related data analysis activity; extension of operations and data analysis activity for OAO-3, SAS-C, IUE, ISEE-A, B,

and C, and AE-E. FY 1980 funding will also support the operations and data analysis activities of the HEAO-C mission and the Solar Maximum Mission (SMM), as well as initiation of preparations for science operations for the Space Telescope, including the initiation of a Space Telescope Science Institute.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

RESEARCH AND ANALYSIS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Supporting research and technology (SR&T)	16,841	19,300	19,300	21,500
Spacelab science payload definition	4,000	4,100	4,100	3,200
Advanced technological development	2,066	---	---	2,500
Data analysis	8,427	9,100	9,100	7,100
Upper atmospheric research	11,600	11,900	11,900	---
Search for extraterrestrial intelligence	---	600	---	---
Total	42,934	45,000	44,400	34,300

OBJECTIVES AND STATUS:

This program provides for the research and technological base necessary to plan and support flight projects. Preliminary studies to define missions and/or payloads requirements are carried out, as are theoretical and ground-based supporting research, and Advanced Technological Development (ATD). Activities included are Supporting Research and Technology (SR&T), Spacelab Science Payload Definition, ATD, and Data Analysis. Beginning in FY 1980, the Upper Atmospheric Research program and directly supporting activities will be included in the Space Applications.

Supporting Research and Technology (SR&T)

The objectives of Supporting Research and Technology are: (1) to enhance the value of current space missions by carrying out supplementary ground based observations and laboratory experiments; (2) to develop theories to explain observed phenomena and predict new ones; (3) to optimize the return expected from future missions by problem definition, development of advanced instrumentation and concepts, and sound definition of proposed new missions and (4) to strengthen the technological base for sensor and instrumentation development and to conduct basic research necessary to support our understanding of Astrophysics and Solar Terrestrial relationships.

Research is supported in several disciplines of space physics and astronomy. The work in space physics is largely devoted to tasks related to the physics of the Earth's environment and comparative studies of other planetary environments, including the study of Sun-Earth environmental factors. The work in solar physics involves studies of the solar atmosphere and the influence of the Sun on interplanetary and planetary environments. Research supported in astrophysics involves studies of stars, galaxies, interstellar and intergalactic matter and cosmic rays. The development of new instruments, laboratory and theoretical studies of basic physical processes, radio observation of solar and galactic processes and observations by ground-based and balloon-borne instruments are also supported.

A major activity in SR&T is theoretical study which provides a balanced research program in Solar Terrestrial physics. As the exploratory phase of research ends and a more mature research phase which seeks consolidated understanding begins, theory must be strengthened to be a healthy and viable partner with experimentation in the quest for detailed physical understanding. Theory integrates a coherent set of hypothetical, conceptual, and programmatic principles forming the general frame of reference. As such, theory can provide the consolidation of empirical and theoretical knowledge necessary for future mission planning to ensure maximum return from future measurement projects.

The FY 1980 budget request is fully consistent with the 1978 recommendations of the Committee on Space Physics of the Space Science Board which determined that "The theoretical component of the space-plasma-physics effort needs to be strengthened by increased support and, most particularly, by encouraging theory to play a central role in the planned development of the field."

During FY 1979, the SR&T program will fund tasks at universities, non-profit and industrial research institutions, NASA Centers, and other government agencies. Current emphasis is being placed on advanced research pertaining to IR detector devices, X-ray imaging devices, and spectrometers.

Spacelab Science Payload Definition

Spacelab Science Payload studies have provided the data necessary to establish a sound foundation for the Physics and Astronomy experiments to be conducted on Shuttle/Spacelab missions. The initial studies concentrated on establishing the feasibility of performing discipline-dedicated missions and multidiscipline missions employing both facility-class and principal investigator-class instrumentation. The studies have identified the benefits which can be realized by re-flying instruments and facilities and have also established the feasibility of Shuttle-borne research laboratories and experiments. The Spacelab Science Payloads will employ many common, reusable facility-type and investigator-class instruments to study phenomena in all astronomy and space physics discipline areas.

Several Multiuser Class instruments have been endorsed by a scientific review committee for flight consideration on future missions. Among the candidate instruments are: Large Area Modular Array (LAMAR), which will

provide very high time resolution studies of variable X-ray sources; and the Shuttle Ultraviolet/Optical Telescope (STARLAB), a meter-class general purpose facility capable of accommodating a wide variety of PI-type instruments.

During FY 1979, further definition involving detailed descriptions of instruments, payload configurations, and operational mission profiles is continuing.

Advanced Technological Development

The Advanced Technological Development (ATD) activities will support planning and definition of new and more advanced science missions in Physics and Astronomy based on careful scientific planning performed together with senior advisory bodies. The project will provide the basis for incorporating emerging technologies and evolving science concepts with scientifically planned Physics and Astronomy missions. After identification of the technology and science requirements, science and spacecraft systems feasibility will be evaluated. Funding will be applied to definition and preliminary design of subsystems and elements critical to eventual mission development, in order that technical readiness and resources may be better known before the missions are proposed for implementation.

Candidate missions for the 1980's that will benefit from the ATD project include Gamma Ray Observatory (GRO), Origin of Plasmas in Earth's Neighborhood (OPEN), the Advanced X-ray Astronomy Facility (AXAF), the Gravity Probe-B (GP-B), and the Solar Probe. The GRO will study the basic physical processes of the universe. From this mission will come fundamental knowledge of the forces that shape the cosmos. The AXAF will study stellar structure and evolution, large scale phenomena, active galaxies, clusters of galaxies and cosmology. The AXAF 1.2 meter class telescope will be capable of a sensitivity approximately 20 times that of HEAO-2. The GP-B will be utilized for carrying out an experimental test of Einstein's General Theory of Relativity in which measurements will be obtained of the relativistic precision of an extremely stable, cryogenic gyroscope in Earth's orbit. The OPEN project will be designed to trace the flow of matter and energy from input by the solar wind to output into the atmosphere; to understand storage and acceleration of plasma in the Earth's neighborhood; and to determine the importance of these phenomena and their variability in our delicately balanced environment. The Solar Probe mission will perform detailed scientific observations of the Sun from a small diameter solar orbit, eventually probing the Sun at mission end.

Data Analysis

Activities supported in this area include the analysis of data acquired from instruments flown on spacecraft, balloons, sounding rockets, and research aircraft as well as from ground-based observatories, with emphasis on correlative studies involving data acquired from several sources. To study given phenomena over an adequate range of important independent variables, it is necessary to process large quantities of data covering extended periods of time. Thus, additional data is processed and analyzed, multi-instrument studies are made, and various proposed models or theories are critically tested by use of the data.

Support for the operation of the National Space Science Data Center (NSSDC) is also provided under this program. The NSSDC, located at the Goddard Space Flight Center (GSFC), was established to serve as a central repository and clearing house for scientific data resulting from space investigations. The Satellite Situation Center at NSSDC computes the expected positions of operational spacecraft, so that data acquisition and analysis efforts can be concentrated at times when several spacecraft are especially favorably situated for correlative geophysical studies. The Skylab ATM data analysis program is currently in its final year. The analyses to date have influenced nearly every aspect of solar physics. In the case of at least one topic (coronal holes), the subject has been greatly expanded as a result of these analyses. The third Skylab Workshop, on Active Regions, is in progress and will, like its two predecessors on Coronal Holes and Flares, result in a published monograph.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The FY 1979 Research and Analysis funding has been reduced by $600 thousand because of the elimination by the Congress of the proposed search for extraterrestrial intelligence research project.

BASIS OF FY 1980 ESTIMATE:

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Supporting Research and Technology.....	16,841	19,300	19,300	21,500

During 1980, emphasis in the supporting research and technology area will be given to those tasks which are critical to maintaining a firm base for a viable Physics and Astronomy program. Special emphasis will be placed on studies for advanced instrumentation which will increase both the sensitivity and resolution of detectors. The goal of these programs is to increase the efficiency and precision of data acquisition in all regions of the specturm. Feasibility and scientific definition studies will be conducted on several potential candidate missions for future years.

In solar physics, ground-based solar optical and radio flare observing programs to complement the Solar Maximum Mission have been organized. Additional ground-based solar velocity field measurements will be made, to expand the new and exciting results obtained so far on the solar convection and circulation processes and on probing the convective envelope of the Sun. Several new efforts based on the theory of solar flares have been started which will help corroboarate the results expected from SMM. Two balloon payloads for the observation of gamma-rays from solar flares will be flown.

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Space plasma physics research places increased emphasis on research to predict the interaction of the different space particle and field regimes, including instabilities that cause ionospheric irregularities and those that result in the acceleration of particles in auroral regions and generation of terrestrial kilometric radiation. More work will be devoted to study of instruments to be employed using the Shuttle/Spacelab as a laboratory in space to perform active, controlled experiments by perturbing the plasma medium with a known stimulus and detecting the response. In Astronomy, work will continue on the development of advanced detectors for future space astronomy missions. In support of the data analysis activities of the International Ultraviolet Explorer (IUE), emphasis will be placed on the theoretical and ground-based observational studies of stellar chromospheres and coronae which are the subjects of a substantial number of the IUE Guest Investigator programs. Studies in infrared astronomy will continue to concentrate on the theories of star formation and the physics of cool, dense, interstellar clouds; as part of this effort, there will be an emphasis placed on observing programs from the southern hemisphere using balloons, airplanes and ground-based telescopes.

The FY 1980 budget request for SR&T will also permit the implementation of the theoretical effort by calling upon university, industrial, and government scientists to develop the necessary base on which to further our understanding of the fundamental physics at work in the solar terrestrial relationship. By developing the theoretical base, NASA will be able to define more precisely the science of the 1980's. The solar terrestrial theoretical activities will be directly supportive of the Physics and Astronomy objective of understanding the interaction of the Sun and the Earth's plasma by establishing the clearly defined point for the consolidation of the knowledge necessary for planning.

In high energy astrophysics, instrument work is directed toward the development of new solid state X-ray imaging devices and crystal spectrometers for use on Spacelab and on future high energy astrophysics free flyer missions. New cosmic ray detectors employing the principle of transition radiation are being developed in order to reach into the unexplored high energy cosmic ray region. Important testing of these instruments is carried out on balloons and sounding rockets.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Spacelab Science Payload Definition.....	4,000	4,100	4,100	3,200

In FY 1980, further payload definition of new concepts and of those presently under study will be performed. The studies will provide descriptions of instruments and facilities, payload configurations and operational mission profiles. In addition, concepts and methods of extending time in orbit beyond the present Spacelab capability are being studied and evaluated. The detailed scientific definition of those facility instruments that are strong candidates for hardware development in the early 1980's will be carried out in FY 1980.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Advanced Technological Development (ATD)	2,066	---	---	2,500

FY 1980 funding will provide for continuation of studies and definition of future missions planned for the 1980's. The FY 1980 ATD funding will allow for the further definition study of the Gamma Ray Observatory (GRO) scientific instrumentation and the advanced development of the gamma ray sensors. Major emphasis will also be on ATD for the Origin of Plasmas in Earth's Neighborhood (OPEN), the Advanced X-ray Astronomy Facility (AXAF), the Gravity Probe-B (GP-B), and the Solar Probe. Within the FY 1980 funding, contractor definition studies will be accomplished to assure the technological and scientific readiness of the candidate future missions.

Data Analysis	8,427	9,100	9,100	7,100

Emphasis in the Data Analysis project, to be carried out at universities and government research centers, will be placed on correlative studies involving data acquired from several sources (spacecraft, balloons, sounding rockets, research aircraft, and ground observatories). FY 1980 funds will also support the operations of the National Space Science Data Center.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

SUBORBITAL PROGRAMS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Sounding rockets	19,899	22,200	22,200	21,700	4-26
Airborne research	3,800	4,600	4,600	4,000	4-27
Balloon program	1,500	2,500	2,500	1,200	4-28
Total	25,199	29,300	29,300	26,900	

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Sounding Rockets	19,899	22,200	22,200	21,700

OBJECTIVES AND STATUS:

The Sounding Rocket program provides a versatile, relatively low cost tool for scientific research in the suborbital space environment. This program provides broad-based support of all of the scientific disciplines, including the study of the Earth's ionosphere and magnetosphere, space plasma physics, stellar astronomy, solar astronomy, and high energy astrophysics. Activities are conducted on both a domestic and an international cooperative basis. The current level of activity is approximately 60 rocket flights per year.

The specific objectives of the Sounding Rocket program are as follows:

1. To conduct a coordinated research program with flight requirements that cannot be met by vehicles with different performance characteristics such as balloons, aircraft and satellites and that do not require long duration satellite observation. Specific areas of study include:

a. The nature, characteristics, and composition of the magnetosphere and near space.

b. The effects of incoming energetic particles and solar radiation on the magnetosphere, including the production of aurorae and the coupling of energy into the atmosphere.

c. The nature, characteristics, and spectra of radiation of the Sun, stars, and other celestial objects.

2. To support the basic objectives of the Physics and Astronomy program by providing the means for flight testing instruments and experiments being developed for flight on satellites, observatories, and space probes; and for calibrating or obtaining vertical profiles in correlation with current orbiting spacecraft.

During 1978, 60 rockets were launched from seven locations in the United States, Canada, Sweden, Norway, Greenland, Australia, and Antarctica. These rockets supported the research activities of more than 50 groups from universities, private industry, NASA field centers, other government agencies and foreign space organizations. Soviet and U.S. rockets were fired from Wallops Flight Center (WFC) in the Joint American-Soviet Particle Intercalibration Experiment with the prime objective of determining the source of the nighttime erosion in the ionosphere.

In Space Plasma Physics, rockets are primarily used for low altitude measurements, vertical profiles and chemical release, none of which can be performed with satellites. Increasing emphasis is being placed on investigating the mechanisms that accelerate particles in the auroral regions.

The Solar Physics sounding rocket program continues to play a major role in the NASA solar program. Activities during 1978 included selection of a launch site for conducting sounding rocket flights during the 1980 solar eclipse over East Africa. During FY 1979, the refurbishment of a payload for those flights is scheduled for completion. From late 1979 through 1980, an aggressive program of flights which will observe the Sun by X-rays is planned in support of the Solar Maximum Mission.

In the astronomy area, continuing emphasis is being placed on development of instruments for measurements of stars and extended sources in both the ultraviolet (UV) and X-ray spectral regions, and on correlative measurements of the same objects in different portions of the electromagnetic spectrum. Of special interest during 1978 was the series of seven sounding rocket flights from the launch site at Woomera, Australia, which made X-ray and UV observations of objects in our galaxy and in certain nearby galaxies which can only be viewed from the Southern Hemisphere. During FY 1979, the first flight test of a negative electron affinity X-ray imager is planned.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funds will provide for continuation of most of the efforts described above. Emphasis is being placed on the 1980 solar eclipse over East Africa, the coordination of near-simultaneous launches of several rocket payloads, on correlation with satellite observations, and on flights flown to make measurements, such as those that depend upon film for data recording, which cannot be made with existing satellites.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Airborne Research	3,800	4,600	4,600	4,000

OBJECTIVES AND STATUS:

Research with instrumented jet aircraft has been an integral part of the overall NASA program in Physics and Astronomy since 1965. The aircraft platform provides a large payload capacity and facilities for extending observations over any region of the Earth. It also may be transported readily to high operational altitudes, near 15 km (50,000 feet) in order to provide a cloud-free site for auroral geophysics experiments and astronomical observations. The possibility of conducting observations at this cloud-free altitude has been essential in

opening to astronomy the infrared region of the electromagnetic spectrum from one micrometer to one millimeter. The airborne platform has the further advantage of enabling scientists to participate directly in space research.

The Airborne Research program has utilized two aircraft, the C-141 instrumented with the 91-cm infrared (IR) telescope and the Lear Jet instrumented for unique individual missions.

The C-141A "Kuiper Airborne Observatory", which began operational flights in 1974, is a full-scale, manned facility. The 91-cm f/13.5 IR telescope operates through an open port, with a pressure bulkhead giving the astronomers a comfortable, shirtsleeve environment in which to work. The telescope floats on a large air bearing that permits hours of accurate stabilization within a few arc seconds. The weight of this observatory is about 16 tons (14.5 metric tons).

During the past year, one of the principal scientific accomplishments was the detection of the first infrared "Bok Globule". These globules are very small dark clouds in our galaxy which appear as black spots on photographs and up to now have been opaque to any radiation. This detection opens up a whole new class of objects that can now have this emission measured directly. During 1979, support will be provided for the February 1979 solar eclipse over the Northwestern United States and Canada and for an expedition to lower latitudes to observe the Galactic Center. In addition, provision has been made for a scheduled airframe inspection for the C-141A.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, Airborne Research funds will be used to continue operations of the Airborne Observatory. Funds will also be applied to support for astronomical groups, acquisition of subsystems, and operations with the Lear Jet.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Balloon Program	1,500	2,500	2,500	1,200

OBJECTIVES AND STATUS:

For the development of scientific experiments for spaceflight and for independent scientific missions, it is necessary to test the instrumentation in the space radiation environment and to make observations at altitudes which are above most of the obscuring effects of the atmosphere, particularly in X-ray and infrared parts of the electromagnetic spectrum. In many instances, it is least expensive to fly these experiments on balloons. The funding for this program is utilized for balloons, helium, launch services, tracking and recovery, while funding for the experiments is provided from the Supporting Research and Technology program.

During 1978, approximately 50 balloons were flown from 11 global sites to support the research activities of approximately 35 organizations. This included a flight over Alice Springs, Australia, which acquired information that confirmed the existence of gamma ray emissions from the galactic center. A narrow gamma ray line was observed at 512 KeV, which is caused by the annihilation of electrons and positrons. Until this observation, there had been no unambiguous evidence for a steady non-solar gamma ray line. The launch of approximately 10 heavy-lift balloons had to be postponed during 1978 due to two consecutive failures. A recovery plan has been initiated and a decision concerning the resumption of heavy-lift balloon flights will be made around mid-February 1979. The FY 1979 funding provides support for approximately 60 flights assumming successful resolution of the program involving heavy-lift balloons.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 funding provides for continuation of the balloon program with some reduction in the number of heavy-lift balloon flights.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

PLANETARY EXPLORATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Pioneer Venus	17,900	---	---	---	---
Galileo	20,950	78,700	78,700	116,100	5-4
Mission Operations and Data Analysis	64,359	59,300	59,300	59,000	5-6
Research and Analysis	43,991	49,100	44,400	45,100	5-8
Total	147,200	187,100	182,400	220,200	
Distribution of Program Amount by Installation:					
Johnson Space Center	8,717	8,470	4,356	6,380	
Marshall Space Flight Center	79	---	2,488	10	
Goddard Space Flight Center	3,041	2,410	3,359	3,830	
Jet Propulsion Laboratory	74,100	110,890	107,675	136,330	
Ames Research Center	27,288	39,400	38,805	44,520	
Langley Research Center	11,000	---	---	---	
Lewis Research Center	80	---	---	---	
Headquarters	22,895	25,930	25,717	29,130	
Total	147,200	187,100	182,400	220,200	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

OFFICE OF SPACE SCIENCE

PLANETARY EXPLORATION PROGRAM

LAUNCH SCHEDULE

Project	Mission	Calendar Year
Galileo	Galileo	1982

OFFICE OF SPACE SCIENCE — PLANETARY EXPLORATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Planetary Program includes scientific exploration of the planets and their satellites, the Moon, the small bodies (comets and asteroids), interplanetary dust, and the charged particles and electromagnetic fields of interplanetary space. The program objectives are to understand the present state, origin and evolution of the solar system, to better understand the Earth through comparative planetological studies, and to understand the relation of the chemical history of the solar system to the origin and evolution of life. The program has been highly successful, with the reconnaissance phase of inner planet exploration now complete and with excellent progress in extending our exploration to the outer planets. The depth of the exploration effort is being increased with more detailed investigation of the inner planets underway and the breadth is ready to be extended to cometary and asteroid exploration. The inner planet exploration was established by Mariner-class missions to Mars, Venus and Mercury. As a result of the Apollo missions and the continuing data analysis, lunar exploration is providing fundamental insights into our solar system's origin and planetary evolution. The Viking mission to Mars has provided both a deepening of our understanding of this planet and a leap forward in our technical capabilities. The Pioneer Venus mission is taking exploration of our nearest planetary neighbor into a new era, especially in terms of atmospheric investigations. The four Pioneer Venus probes and the transporter spacecraft entered the atmosphere of Venus on December 9, 1978, and returned a large volume of high quality data that are now undergoing detailed analysis. The Pioneer Venus orbiter was successfully inserted into Venus orbit on December 4, 1978, and will continue to return valuable data for months.

Outer planet exploration, begun several years ago when Pioneers 10 and 11 flew by Jupiter, will be given a major impetus in 1979 by two Voyager spacecraft flybys of Jupiter and by the Pioneer 11 flyby of Saturn. The two Voyagers will continue on to Saturn for 1980/1981 encounters and the second spacecraft could then proceed to Uranus for a 1986 encounter.

Pioneer 10 will soon be beyond the orbit of Uranus and is moving inexorably out of our solar system. It is gathering unique data about the outer portions of our solar system and searching for the transition between interplanetary and interstellar space. Pioneers 6-9 and Helios 1 and 2 remain in good condition orbiting the Sun and periodically returning data about the interplanetary medium in the inner solar system. FY 1980 funds will support the extended missions of Pioneer 6-11, the Pioneer Venus Orbiter, Helios 1 and 2 and the cruise operations of the Voyagers moving on to Saturn.

The Galileo mission is a cooperative effort between the United States and the Federal Republic of Germany, which will carry forward the exploration of Jupiter and its satellites. Launch is planned for January 1982, using the Space Transportation System. Science experiments have been selected from within the United States and from Europe. In the last year, progress has been made and the development effort is proceeding on schedule. FY 1980 funds will be used to continue this development effort.

Strong research and analysis programs continue to provide both a basic framework for the Planetary Program and a coordinated effort of analysis to take full advantage of the data that have already been acquired. These programs involve many different types of effort, including data and sample analysis, telescopic observations, theoretical and laboratory studies, and the definition of instruments needed for future missions. Many of the achievements of the Planetary Exploration program came from the research and analysis programs where all ideas are subject to intense scrutiny, and where the close association of the various research groups leads to the rapid dissemination of new concepts. Research using lunar samples, meteorites and cosmic dust remains a key element of the Planetary Program. The lunar sample effort is mission-oriented and is coordinated with lunar sample research funded by the National Science Foundation. These research programs are closely associated with the planning efforts to define the scientific rationale and the technology needs for future planetary program flight missions.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

GALILEO

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	11,660	55,900	53,470	83,260
Experiments	7,590	22,000	19,374	24,266
Ground operations	1,700	800	5,856	8,574
Total	20,950	78,700	78,700	116,100
Space Transportation System Operations	(900)	(5,500)	(5,500)	(16,900)

OBJECTIVES AND STATUS:

The Galileo mission, which will conduct direct and long-duration studies of Jupiter, is a vital link in providing the continuity, balance and orderly progression of our program of exploration of the solar system.

The objectives of this program are to conduct a comprehensive exploration of Jupiter, its atmosphere, magnetosphere and satellites by a single mission, utilizing a new deep space spacecraft concept which combines both remote sensing and direct measurements on a combined three-axis stabilized/spinning spacecraft with an atmospheric probe.

The orbiter/probe combination will be launched in January 1982, by the Space Transportation System. The entry probe, designed to survive a descent to a pressure of at least 10 Earth atmospheres, will be separated from the orbiter prior to the Jupiter encounter. Scientific data gathered by the probe during entry will be relayed to Earth via the orbiter. Shortly thereafter, the orbiter will be inserted into orbit around Jupiter and the orbit will be periodically adjusted to permit multiple encounters of the satellites of Jupiter.

In FY 1979, the design, development and fabrication activities will proceed. Requirements imposed by the science and design of the mission are being translated into designs for the major elements of Galileo--the probe and orbiter spacecraft, the mission operations, the spacecraft propulsion module, the on-board power systems, and the Space Transportation System interface.

CHANGE FROM FY 1979 BUDGET ESTIMATE:

The FY 1979 Galileo estimate remains unchanged in total; however, adjustments have been made within the project elements. These adjustments are of two types, both based on experience with the Voyager project: (1) the Ground Operations estimate was increased by approximately $3.0 million to reflect a functional transfer of certain responsibilities for mission-wide engineering activities (data system) and for preparation of flight software; and (2) the Ground Operations estimate was also increased by $2.0 million to better balance the spacecraft design schedule with the design effort devoted to mission operations software.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding requirements will provide for fabrication and test of the Galileo science instruments, the probe and the orbiter spacecraft. Significant milestones include the Orbiter Systems critical design review in the first quarter of FY 1980 and the project capabilities review in the fourth quarter of FY 1980. Integration and testing will occur in FY 1981.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

MISSION OPERATIONS AND DATA ANALYSIS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Voyager basic mission	16,025	14,400	15,175	19,000
Pioneer Venus basic and extended mission	1,100	10,500	10,500	9,800
Pioneer 6-11 extended mission	2,106	3,900	3,125	4,000
Helios extended mission	700	200	200	---
Viking extended mission	20,000	5,000	5,000	---
Planetary flight support	24,428	25,300	25,300	26,200
Total	64,359	59,300	59,300	59,000

OBJECTIVES AND STATUS:

The Mission Operations and Data Analysis Program funds the operations phase of planetary missions after development, launch, and initial inflight checkout are complete. It also provides for multimission flight support. Currently active planetary missions being supported within mission operations are Voyager, Pioneer Venus, Pioneer 6-11, Helios and Viking.

The objective of the Voyager mission to the outer planets is to conduct scientific studies of the Jupiter and Saturn planetary systems, including their numerous satellites and the rings of Saturn. If conditions are favorable, one of the two Voyager spacecraft may also go on to Uranus to investigate this exciting planet. While the two spacecraft are cruising to the outer planets, they will also be performing new investigations of the interplanetary medium. Since their launches in the summer of 1977, the two Voyager spacecraft have been cruising on trajectories to Jupiter. Both spacecraft are in good condition for their encounters with Jupiter and its satellites. The primary radio receiver of Voyager 2 failed during the past year; however, the spacecraft is being operated successfully using its backup receiver, even though that equipment is somewhat impaired by a component failure. Encounter operations for Voyager 1 will begin the first week of January 1979. Closest approach to Jupiter will occur on March 5, 1979, followed in a few hours by close encounters with the satellites Io, Europa, Ganymede, and Callisto. Similar operations for Voyager 2 will commence in April 1979, with closest approach at Jupiter on July 9, 1979. A wealth of new planetary data is expected from the investigations provided by the Voyagers as they traverse the immense Jovian system. After their encounters at Jupiter, the two spacecraft will be accelerated on trajectories to Saturn, arriving there in November 1980 and August 1981.

The objectives for Pioneer Venus are to obtain detailed information on the Venusian atmosphere and to investigate the planet's environment. The mission is carried out by two spacecraft: an orbiter launched in May 1978 and a multiprobe launched in August 1978. The orbiter arrived at Venus on December 4, 1978, and was put into a highly elliptic orbit that approaches within 150 kilometers of the surface. On December 9, 1978, the four probes and multiprobe bus entered the atmosphere. The probes made measurements as they descended to the surface at widely separated points, and the bus also collected data. One of the key objectives is to learn why Venus, so Earth-like in many respects, has an atmosphere so different. The mission has been, and continues to be, an outstanding success.

The objective of Pioneer 6-9 is to explore interplanetary space at radial distances from the Sun varying from 0.75 to 1.1 AU. (The Earth's distance from the Sun is 1 AU, an astronomical unit). The objectives of Pioneer 10 and 11 are to explore space beyond one AU, the Asteroid Belt and the environment of Jupiter. Pioneers 6-9, with launches starting back in 1965, are still operational, but are now generally tracked only when unusual solar activities or special alignment with other spacecraft occur. Pioneer 10, launched in 1972, reached Jupiter in December 1973, and the gravity of the massive planet provided the extra impetus to take Pioneer 10 out of the solar system. Pioneer 11, launched in 1973, passed Jupiter in December 1974 and the spacecraft trajectory was influenced by the planet's gravity field in such a way that it will fly by Saturn in 1979. Both spacecraft have returned excellent data and continue successful operation.

Planetary Flight Support provides for mission control and other activities which support the tracking, telemetry and command functions for all planetary spacecraft. The activities include general purpose scientific and engineering computing capabilities at the Jet Propulsion Laboratory (JPL), and selected project functions such as preparation of data records, computer analysis time, and provision for the mission support areas. These functions are performed at the Mission Control and Computing Center at JPL.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

Voyager funding requirements in FY 1979 increased by $775 thousand from last year's budget estimate. The additional funds were necessary to provide for increased mission operations staffing to respond to spacecraft anomalies and operational complexities. The increase reflects an offset by a reduction in the amount to support Pioneer 6-11 cruise operations.

BASIS OF FY 1980 ESTIMATE:

The Voyager FY 1980 funding requirements will provide for mission operations during the cruise period between the Jupiter and Saturn encounters. The project scientists will be engaged in analyzing and publishing the results from the two Jupiter encounters in 1979. The flight team will be operating the two spacecraft while each Voyager continues its interplanetary observations. The flight team will also be developing the sequences and software for the Saturn encounters, which will occur in November 1980 and August 1981. Voyager 1's encounter period at Saturn will start with concentrated observations of the ringed planet and its many satellites in late August 1980.

The Pioneer Venus basic mission funds for FY 1980 will support processing and analysis of the data obtained during the multiprobe entry and during the first 243 days of orbital operations. Funds for the extended mission will support continued orbiter operations beyond this period.

For Pioneer 6-11, FY 1980 funds will provide for mission operation and data analysis with emphasis on data from the Saturn encounter of Pioneer 11.

Planetary Flight Support funds for FY 1980 will provide mission control and computing support for all active planetary spacecraft.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

RESEARCH AND ANALYSIS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Supporting research and technology	37,899	34,200	29,500	33,300	5-10
Advanced programs	6,092	5,400	5,400	5,800	5-11
Mars data analysis	---	4,500	4,500	6,000	5-11
Solar electric propulsion/comet studies	---	5,000	5,000	---	---
Total	43,991	49,100	44,400	45,100	

OBJECTIVES AND STATUS:

The Research and Analysis program contains the supporting programs required to assure that data and samples returned from flight missions are fully exploited, to undertake complementary laboratory and theoretical efforts, and to define the science rationale and develop required technology to undertake future planetary missions. The individual programs within the Research and Analysis effort have been restructured to integrate similar functions. Beginning in FY 1980, funding for Solar Electric Propulsion studies and evaluation is included in the Space Flight Flight Operations program, under the cognizance of the Office of Space Transportation Systems.

Supporting Research and Technology -- The Planetary Astronomy activity includes all planetary observations made by ground-based, airborne and Earth-orbital telescopes. Observations are made at a wide range of wavelengths from ultraviolet to radio, and the rate of new discoveries continues to be high. The data acquired

are used both for basic research in support of planetary program objectives and for direct support of specific flight missions. In the Spring of 1979, the new Infrared Telescope facility in Hawaii will commence planetary observations including support of the Voyager encounters of Jupiter and Saturn.

The Planetary Atmospheres activity includes data analysis, laboratory and theory efforts and flight instrument definition. The properties of other planetary atmospheres are amenable to measurement and can aid us in better understanding of our own weather and climate. This activity has an excellent record of science contributions. Pioneer Venus and Voyager are examples of missions that are returning valuable data that will significantly contribute to this research area and will provide an improved understanding of planetary atmospheres in general.

The Planetary Geochemistry and Geophysics activity is broad in scope and includes studies of the composition and structure of all the classes of solar system objects, the synthesis of data from all sources that relate to the origin and evolution of the solar system, and the definition of instruments for future flight missions. The program supports the synthesis of planetary data already obtained, and the assembly of information needed to prepare for future missions.

To date, the Planetary Geology activity has focused on studies of the inner planets (including the Moon). Shortly, Voyager data pertaining to the Galilean satellites of Jupiter will provide a new dimension for this effort. The geology program is a broadly based effort in which comparative studies of common processes affecting all the inner planets provide a powerful technique for unravelling individual planetary histories, including their early states. Imaging data, both from spacecraft and from ground-based radar, provide the basis for much of the data analysis.

The Planetary Materials activity supports an active scientific effort to determine directly the chemistry, mineral composition, age, physical properties, and other characteristics of returned lunar samples and of meteorites that fall to Earth. These studies continue to yield new and otherwise unobtainable information about the solar system, particularly about its early history. At the request of Congress, NASA and the National Science Foundation have analyzed the lunar sample program and have concluded that the National Science Foundation should recognize the growing importance of planetary science and increase its support for high quality research in the area of Earth and planetary science, while NASA should maintain a balanced program of work on extraterrestrial materials consistent with its mission. The FY 1980 lunar sample analysis effort included in the Planetary Materials Program reflects this conclusion of the joint study.

Advanced Programs -- The Advanced Programs activity combines the work of Advanced Studies and Advanced Technical Development, which have been budgeted in previous years as separate items. This year, because of the complementary and interactive nature of these efforts, they have been combined into a single item. The objective of Advanced Programs is to provide planning and preparation for the systematic exploration of the solar system on a scientifically and technically sound basis. Prospective planetary missions are identified and defined through long-range studies; their technological and fiscal feasibility is evaluated, and their

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scientific merit is assessed through interaction with the scientific community. For near-term missions, detailed project planning and technology readiness studies are carried out so that these missions may be undertaken on schedule and within fiscal constraints.

Current studies and supporting activities cover such possible future missions as the Venus Orbiting Imaging Radar (VOIR), a comet mission, a Saturn orbiter mission with Saturn and Titan probes, and an asteroid multiple rendezvous mission.

Mars Data Analysis -- The Mars Data Analysis activity continues in FY 1980 to assure that we fully capitalize on the wealth of data provided by Viking. The activity covers the broad scope of the returned data--biology, chemistry, geology, meteorology, etc. The quality of the first proposals submitted was excellent. FY 1980 funding continues this effort.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The reduction of $4,700,000 in the FY 1979 Supporting Research and Technology Program is a result of Congressional action in reducing the FY 1979 appropriations and requesting NASA and the National Science Foundation to review the lunar sample analysis program.

BASIS OF FY 1980 ESTIMATE:

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Supporting Research and Technology.....	37,899	34,200	29,500	33,300

During FY 1980, research efforts will continue in the areas of Planetary Astronomy, Planetary Atmospheres, Planetary Geochemistry and Geophysics, Planetary Geology, and Planetary Materials. Infrared telescopic observations of Jupiter and Saturn will be undertaken in support of the Voyager missions, and radar telescopes will be used to continue the investigation of Venus and other solar system bodies. Other significant observations will be conducted both to increase our knowledge of the outer planets and the small bodies of the solar system and to advance our readiness for future missions. A variety of efforts will be pursued to improve our understanding of planetary atmospheres, including laboratory studies of reactions in deep atmospheres and in tenuous cometary atmospheres, modeling of global circulation patterns, and the definition of instruments for future missions. Instrument definition is of similar importance in the geochemistry-geophysics area where research efforts will be made to continue to better understand the present state and evolution of individual bodies and of the solar system in general. Geology research will be directed at specific problems in

understanding the various processes that have shaped planetary surfaces and will also include a cartography effort based on the Galilean satellite imaging data acquired by Voyager. Analysis of lunar samples, meteorites, and cosmic particles will continue in order to determine their chemical and physical properties and thereby to derive their origin and evolutionary history.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Advanced Programs	6,092	5,400	5,400	5,800

In FY 1980, the major effort in Advanced Programs will be devoted to continued preparations for the Venus Orbiting Imaging Radar Mission, including more detailed mission definition studies and advanced technology development. Work on the Mars study efforts will continue to provide more detailed mission and system concepts for possible future Mars missions, building on the Viking achievements. Other studies will include continuation of mission definition for a Saturn orbiter with probes into Saturn and its moon Titan, comet mission definition and science selection, and further studies of an asteroid multiple rendezvous mission.

Mars Data Analysis	---	4,500	4,500	6,000

The Mars Data Analysis activity began in FY 1979 and over 80 research efforts have been initiated in a wide range of discipline areas such as biology, chemistry, geology, and meteorology. The FY 1980 funds will provide for the continuation and/or completion of these efforts and the initiation of a relatively few additional new analyses.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

LIFE SCIENCES PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Life sciences flight experiments	9,000	12,400	11,900	12,900	6-3
Vestibular function research	1,500	3,800	3,800	3,700	6-4
Research and analysis	22,800	24,400	24,400	27,300	6-5
Total	33,300	40,600	40,100	43,900	
Distribution of Program Amount by Installation:					
Johnson Space Center	13,024	15,425	16,200	16,650	
Kennedy Space Center	92	300	400	650	
National Space Technology Laboratories	50	50	---	---	
Jet Propulsion Laboratory	1,578	1,310	1,710	2,050	
Ames Research Center	12,552	17,867	16,117	18,480	
Dryden Flight Research Center	140	100	185	200	
Lewis Research Center	56	---	---	---	
Headquarters	5,808	5,548	5,488	5,870	
Total	33,300	40,600	40,100	43,900	

OFFICE OF SPACE SCIENCE

LIFE SCIENCES PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Life Sciences program is to conduct research on the origin and nature of life where access to space has provided us with a new opportunity. This will help us to discover and mitigate the effects of the space environment on humans to facilitate their safe, useful participation in space activities. The realization of this goal, which is intimately linked to our understanding of the basic mechanisms of biological and medical processes, is achieved through a program of research conducted both on Earth and in space. A continuum flows from the ground-based research activities to the flight experiments, and then from flight findings to laboratory work on the Earth. The Life Sciences program is a composite of disciplines addressing all space-related problems in biology and medicine.

The Life Sciences program is composed of two major program thrusts. The first is a program consisting of flight and ground-based experiments, whereby the physiological effects of the space environment on humans are explored. The unique properties of space (e.g., zero-gravity) provide, for the first time in our history, an opportunity to explore significant problems in biology under a set of conditions that cannot be created here on Earth. The second thrust is our studies in planetary biology, with special emphasis on a problem of profound philosophical and scientific significance: the origins and distribution of life in the universe.

Spacelab-1 will be available for inflight research activities in 1981. In preparation for the early flights, and subsequent selection of Shuttle passengers, ground-based research is being conducted presently on the limits of physiological tolerance to space flight stresses. Seven life sciences experiments are being developed by NASA for the Spacelab-1 mission. These experiments emphasize the exploration of the effects of space flight on humans, such as changes in vestibular function and hematological indices and effects of space radiation, and some relate to basic biological sciences, such as the effect of gravity on plant growth and biological rhythms.

The first Spacelab flight dedicated entirely to Life Sciences is planned for 1982. Experiment proposals in response to our Announcement of Opportunity for future Life Sciences Shuttle/Spacelab payloads flights were received in 1978 and are currently being reviewed. Selections for the first dedicated flight will be made in 1979. Development of general purpose equipment for use on these life sciences flights is in progress.

A significant highlight of the Life Sciences program is NASA's ongoing participation in the joint US/USSR Biological Satellite program which will include a Cosmos launch in August/September 1979. Thirteen US experiments will be flown on this flight; these experiments will explore relevant medical and biological problems. In addition, advance planning has been initiated for future US participation in a 1981 USSR biological satellite mission. In conjunction with the flight experiments outlined above, relevant ground-based research continues to provide an adequate data base and rationale for future flight experiments.

Planetary biology is the second major program thrust. The goal is to understand the origins and distribution of life throughout the universe. Particular emphasis is placed on discovering the relationships which link the formation of the solar system to the beginnings of life. The impact of the presence or absence of life on the subsequent evolution of a planet is just beginning to be realized.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

LIFE SCIENCES FLIGHT EXPERIMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Life sciences flight experiments	9,000	12,400	11,900	12,900
Space transportation system operations	(---)	(---)	(---)	(2,800)

OBJECTIVES AND STATUS:

The objective of the Life Sciences Flight Experiments program is to expand our understanding of certain basic biological and medical processes. This knowledge will improve human ability to function appropriately in the space environment. The program includes the whole process of planning, experiment development, inflight operations and data analysis. The experiments flown will deal with the effects of weightlessness, and other unique space environmental conditions, on living systems.

Proposals have been received in response to our Announcement of Opportunity. The initial selection of flight experiments for the first flight will be made in mid-1979. The proposals encompass a wide range of science endeavors in the disciplines of biology, medicine, behavioral performance, and technology.

The plan is to provide general-purpose flight hardware required for the flight experiments, thus eliminating unnecessary duplication of equipment.

CHANGE FROM FY 1979 BUDGET ESTIMATE:

The decrease of $500 thousand in the FY 1979 estimate is the result of the Congress' general reduction in NASA's FY 1979 R&D appropriation request, and is consistent with a delay in the early Shuttle/Spacelab flights.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, the selected flight instruments will be in design. The general equipment necessary to support the flight experiments will continue to be developed, and the development of ground support equipment for payload test and integration will proceed.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

VESTIBULAR FUNCTION RESEARCH

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Vestibular Function Research	1,500	3,800	3,800	3,700

OBJECTIVES AND STATUS:

Preliminary results from U.S. as well as USSR manned flight missions have indicated that a number of flight personnel experienced "motion-sickness" during flight. In varying degrees, performance was compromised during the illness. It is fairly well accepted that the neurophysiology associated with the vestibular organ is responsible for the illness.

The Vestibular Function Research (VFR) project provides for development of a reusable flight facility to conduct investigations on the otolith and the neurosensory response meachnisms associated with motion in a zero-gravity environment. The response to the Life Sciences Announcement of Opportunity reflects a need by the vestibular research community for an opportunity to conduct investigations in a unique VFR facility. The responses also indicate a need for reconsideration of our approach to implementation of this facility. Accordingly, the program will continue definition and design activities in FY 1979 and will start development in FY 1980.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, selected investigators will develop the flight experiment protocols, and initiate specific ground testing to generate biological records for baseline ground data. Instrumentation methods will be

examined and evaluated. A prototype of the flight hardware, including both tilt and centrifuge subsystems, will undergo design, fabrication and qualification tests.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

RESEARCH AND ANALYSIS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Life sciences supporting research and technology	18,000	20,400	20,400	23,000
Planetary biology and protection	4,800	4,000	4,000	4,300
Total	22,800	24,400	24,400	27,300

OBJECTIVES AND STATUS:

The Research and Analysis activities of the Life Sciences program support the ground-based research in space-related biological and biomedical problem areas that have been identified in previous flights or have been determined to be highly probable in future flights.

The Life Sciences Supporting Research and Technology program is comprised essentially of three elements: (1) biomedical research, (2) space biology, and (3) life support systems. The primary function of biomedical research is to improve our understanding of physiological and behavorial effects of spaceflight and the attendant hazards to humans, for the purpose of enhancing his capabilities and safety in space. The program is designed to elucidate the mechanisms of adverse physiological effects of the space environment, and to identify techniques and devices for the prevention and correction of these effects. Specific operational requirements such as medical selection and retention criteria, together with environmental protection requirements, are continuously reevaluated and updated. There is a continuum of basic and applied research which ranges broadly from cardiovascular, vestibular, skeletal and other physiological areas to clinical medicine and special hazards such as radiation.

The space biology activity investigates the role of gravity on biological processes so as to develop hypotheses of how gravity may have influenced the functions and shapes of the various life forms. The program provides basic ground-based information necessary both for optimizing the selection of flight experiments, and for designing future life support systems.

The life support systems activity concentrates on finding cost-effective alternatives to presently utilized open-loop life support systems by the development and demonstration of physio-chemical and biological regenerative systems. These systems will minimize the requirement for expendables and supplies on flights of long duration. The goal of this effort is to provide the basis for the eventual support of humans in space for a long duration.

The thrust of the planetary biology research activity is to understand the origins and distribution of life, or precursor molecules of life, throughout the universe. In particular, such efforts hope to provide an understanding of the evolutionary pathways that led to the emergence of life from primordial molecules presumed to be present after the formation of this planet. Furthermore, data from analysis of the Mars soil and from extreme environments on earth (e.g., the Antarctica and Precambrian rocks) has provided new awareness for future research.

The planetary protection program provides updated methodologies for the control of biological and particulate contamination of all outbound spacecraft. In addition, methodologies and strategy for sample return missions are being evaluated.

BASIS OF FY 1980 ESTIMATE:

The biomedical research will continue to investigate the basic mechanisms, potential risks, and acceptable countermeasures associated with sustaining humans in space, emphasizing ground-based investigations.

The space biology program will expand to provide adequate ground-based support data for the anticipated increased number of flight experiments in the Shuttle/Spacelab program. Emphasis will be placed on identifying relationships between stress on biological processes and gravity.

The research in advanced life support systems will expand to include preliminary studies to investigate basic biological processes and physical-chemical methods which could provide the capability to recycle waste, food, atmosphere, and water.

The planetary biology program will emphasize research in chemical evolution and the origin of life. Analysis of the data from the Martian soil has provided us with significant insights regarding the distribution of carbon molecules in the solar system, and has suggested novel avenues for future research.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE AND TERRESTRIAL APPLICATIONS

Programs	1978 Actual	Budget Plan 1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Space applications	234,800	274,300	274,800	332,300
Technology utilization	9,100	9,100	9,100	12,100
Total	243,900	283,400	283,900	344,400

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS

SPACE APPLICATIONS PROGRAMS

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Resource observations	102,845	136,650	139,150	141,400	7-7
Environmental observations	75,415	67,600	67,900	117,200	7-20
Applications systems	13,340	18,200	15,700	24,200	7-38
Technology transfer	10,400	10,950	10,950	10,300	7-43
Materials processing in space	13,650	20,400	20,400	19,800	7-45
Space communications	19,150	20,500	20,700	19,400	7-50
Total	234,800	274,300	274,800	332,300	
Distribution of Program Amount by Installation:					
Johnson Space Center	27,206	21,875	24,347	31,150	
Kennedy Space Center	535	500	703	825	
Marshall Space Flight Center	16,679	32,550	27,506	29,525	
National Space Technology Laboratories	3,890	3,450	2,955	3,750	
Goddard Space Flight Center	126,683	160,470	156,398	184,100	
Jet Propulsion Laboratory	28,593	18,545	22,612	22,300	
Wallops Flight Center	3,533	2,610	2,952	4,125	
Ames Research Center	6,191	6,000	6,285	10,550	
Langley Research Center	9,035	16,600	12,134	19,125	
Lewis Research Center	3,030	2,850	3,735	5,125	
Headquarters	9,425	8,850	15,173	21,725	
Total	234,800	274,300	274,800	332,300	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS — SPACE APPLICATIONS PROGRAM

FLIGHT SCHEDULE

Project	Mission	Calendar Year
Resource Observations:		
Earth Resources Technology Satellites	Launch of LANDSAT-D	1981
Magnetic Field Satellite	Launch of MAGSAT	1979
Shuttle/Spacelab Payload Development	Orbital Flight Test Missions	1980
	Spacelab Payloads	Beginning in 1981
Environmental Observations:		
Stratospheric Aerosol and Gas Experiment	Launch of SAGE	1979
Global Atmospheric Research Program	First GARP Global Experiment	1978-1979
Shuttle/Spacelab Payload Development	Orbital Flight Test Missions	1980
	Spacelab Payloads	Beginning in 1981
Earth Radiation Budget Experiment	Launch of ERBS-A	1983
	ERB instrument to be launched on NOAA F&G	1982-1984
Halogen Occultation Experiment	HALOE instrument to be launched on Spacelab mission and ERBS-A	1982-1983
Materials Processing in Space:		
Sounding Rocket Missions	Launch about 2 annually	1979-1980
	Flight of Materials Experiment Assembly	Beginning in 1980
Shuttle/Spacelab Payload Development	Spacelab Payloads	Beginning in 1982
Space Communications:		
Search and Rescue Mission	Instruments to be launched on NOAA (TIROS-N series) spacecraft	1982-1984
Shuttle/Spacelab Payload Development	Flight of Adaptive Multibeam Antenna	1982

FLIGHT SCHEDULE

Project	Mission	Calendar Year
Reimbursable Missions:		
GOES*	Launch of GOES D through F	1980-1983 (Subject to call-up by NOAA)
NOAA*	Launch of NOAA A-G	1979-1984 (Subject to call-up by NOAA)

*National Oceanic and Atmospheric Administration (NOAA) funded.

OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS — SPACE APPLICATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Space Applications program is to conduct research and development activities that demonstrate and transfer space-related technology, systems and other capabilities which can be effectively used for down-to-Earth practical benefits. These activities are grouped in the following general areas: Resource Observations, Environmental Observations, Applications Systems, Technology Transfer, Materials Processing in Space, and Space Communications.

In each of these areas, programs are being conducted and planned to contribute to the solution of pressing national, as well as international, problems and needs.

Resource Observations -- This program addresses needs for information of vital economic value to the U.S. and of importance to global humanitarian concerns such as the world's food and energy supplies. The principal objectives are to develop the use of space and space technology to provide the Nation with a global capability for the monitoring and management of essential agricultural commodities, for water resources management, for mineral and petroleum exploration, for land use assessment and for the eventual forecasting of crustal hazards. Inherent in these objectives is the involvement of the users of space-derived information in the development, test, verification and application of these techniques.

Principal activities include the identification of user information needs, the understanding and development of remote sensing techniques, provision for the routine acquisition of space data, experimental projects with users, and the eventual evolution to routine global data collection systems. Currently Landsats-2 and -3 are providing a wide variety of useful data. Landsat-D, with improved capabilities, is under development and will be launched in 1981. Other experiments intended to test the applicability of microwave measurements and stereoscopic imaging for geological studies are planned for flight on the early Shuttle missions. Studies are also underway to evaluate the use of space systems for global stereoscopic imagery for resource exploration. Joint research activities with other Federal agencies are planned to advance our knowledge of how to apply multiple data sources in improving agricultural early warning and crop commodity forecasting and in advancing the scientific understanding of the solid Earth.

Environmental Observations -- Understanding the dynamics and limitations of our environment is essential to our long-term survival. NASA's Environmental Observations Program aims at improving the understanding of processes in the atmosphere and oceans, providing space observations of parameters involved in these processes

and extending the capabilities to predict environmental phenomena and their interaction with human activities. The interactions among these processes and the interrelationship of the atmosphere, ocean, land and space environments can only be fully studied on a global basis from space. Capitalizing on this global perspective, the program objectives are to study tropospheric and stratospheric pollution, to measure the radiative budget of our planet, to improve numerical weather prediction, and to develop remote sensing of ocean surface properties. NASA's program includes research efforts plus the development, demonstration and transfer of new technology for global and synoptic measurements. Research satellites give a special view of the radiative, chemical, and dynamic processes occurring in the atmosphere and oceans.

With the transfer of organizational responsibility for the Upper Atmospheric Research Program from the Office of Space Science, the Environmental Observations Program now includes studies of all of the layers of the atmosphere from the turbopause (100-110 km) down to and including the upper layers of the oceans. The program areas now include: (1) Upper Atmospheric Research, (2) Global Weather, (3) Severe Storms, (4) Climate, (5) Environmental Quality (including Stratospheric Pollution and Tropospheric Pollution), and (6) Oceanic Processes (including Water Pollution, Ocean Dynamics, Ice Dynamics, and Coastal Processes). This integrated approach encompasses the diverse fields of meteorology, climatology, atmospheric chemistry, atmospheric physics, and oceanography, and focuses on the special contributions of space-derived data. In support of these programs, four spacecraft were launched in 1978: SEASAT, TIROS-N, GOES-3 and NIMBUS-7. The Stratospheric Aerosol and Gas Experiment will be launched in 1979. Work is continuing on design and development of the Earth Radiation Budget Experiment, the Halogen Occultation Experiment, and Shuttle/Spacelab payloads, such as the Atmospheric Cloud Physics Laboratory.

Applications Systems -- This program supports Space Applications requirements for use of airborne facilities, definition of data management technology requirements, and payload mission design and integration. Program responsibilities also include definition and coordination of payload requirements, assessment of Space Transportation System accommodation requirements and payload integration and operations analysis.

Technology Transfer -- In recent years, remote sensing technology has matured significantly and is now increasingly able to provide much of the resource and environmental information needed to meet Federal and other legislative requirements, to aid in the search for new resources, and to meet other commercial demands for synoptic information such as agricultural production forecasting. The objectives of the Remote Sensing Technology Transfer Program are to provide for the validation, transfer and widespread dissemination of proven technology applications to operational use, maximizing the benefit to the Nation from NASA technology. Because operational jurisdiction for use of this technology rests elsewhere, the program assists in the establishment of self-sustaining user capabilities for the application of space technology outside of NASA in public and private sectors and provides a communication channel through which user needs can be assessed and factored into future NASA program planning.

Materials Processing in Space -- The Materials Processing in Space program emphasizes the fundamental science and technology of processing materials under conditions that allow detailed examination of the constraints imposed by gravitational forces. Its goal is to test and demonstrate the capabilities of the space environment for materials processing and provide opportunities for independently funded users to exploit space flight for processing activities related to their own needs. The program's ground-based research will be enhanced in accordance with recent recommendations from the National Academy of Sciences to broaden the scientific basis for future efforts. New activities will be initiated in response to proposals from the scientific community, while ongoing effort will emphasize work on focused problems that are important for both science and technology. The Space Processing Applications Rocket (SPAR) project will conclude its flight operations with expendable sounding rockets and prepare for continuing STS experimentation, using self-contained packages of rocket payload equipment mounted in the Shuttle payload bay by means of the Materials Experiment Assembly. Design work on the program's initial group of STS payload equipment will be completed in FY 1980, leading to fabrication in FY 1981 and flight on STS missions in 1982. This equipment will be used to perform experiments to demonstrate the utility of space flight for materials research and to prepare a scientific data base for applications that will be developed in later years.

Space Communications -- American private enterprise built a new industry upon NASA's early pioneering work in satellite communications. Industry now offers strong support for a renewed NASA effort in satellite communications R&D in order to assure a large U.S. participation in this segment of a rapidly growing worldwide telecommunications market. In FY 1980, NASA will begin focusing on the development of technology to increase the usable capacity of the radio frequency spectrum and geosynchronous orbit. In particular, NASA will be working toward the development of multi-beam antennas and on-board switching techniques. In FY 1980, us experiments and demonstrations on NASA's ATS-1 and ATS-3 experimental satellites will continue. By the of FY 1979, public service user experiments on ATS-6 and CTS will have been completed, and FY 1980 will first of two phase-out years for those two satellites. A significant effort is being undertaken to provide technical consultation and support to U.S. Government agencies, including NASA, participating in the 1979 World Administrative Radio Conference (WARC)--the first of its kind since 1959.

Work is continuing on the development of an experimental Search and Rescue Mission. This system will employ sensitive receivers and high gain antennas, carried on spacecraft, to demonstrate the feasibility of obtaining a significant increase in the capability to detect and locate distress signals from general aviation aircraft and certain marine vessels. This interagency program is being conducted jointly with Canada and France; discussions with the Soviet Union are also underway. The launch of the first operational meteorological satellite equipped with the search and rescue instrumentation is planned for 1982.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

RESOURCE OBSERVATIONS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
LANDSAT-3	3,155	700	700	---	
LANDSAT-D	48,200	97,500	97,500	89,800	7-9
Heat capacity mapping mission	600	300	300	---	
Magnetic field satellite	10,500	3,900	3,900	1,600	7-11
Shuttle/Spacelab payload development	3,620	6,000	6,000	1,600	7-12
Extended mission operations	200	---	350	1,500	7-13
Geodynamics	6,940	8,600	8,200	13,100	7-14
Applied research and data analysis	29,630	19,650	22,200	33,800	7-16
Total	102,845	136,650	139,150	141,400	

OBJECTIVES AND STATUS:

The goal of the Resources Observations Program is to develop and demonstrate the application of space observations and space techniques to the acquisition of important information regarding the Earth's agricultural, water, land, mineral, and energy resources, and to acquire new scientific information on the Earth's dynamic characteristics to allow a physical description of the planet. To achieve this goal, the program is focused towards: (1) the development of basic techniques for sensing the characteristics of the Earth's surface and extracting useful information from the remotely sensed data from space; (2) the development of precise measurements of the movements of the Earth's crust and its other dynamic characteristics to support research in earthquake mechanisms; (3) the conduct of joint research and development programs with elements of the Federal, public and private sectors that have major responsibilities and information needs in managing resources or are interested in the use of space-derived data to augment other information sources; (4) the provision of remotely sensed data from space on a continuing basis to a variety of users; and (5) the evolutionary development of the global space sensing capability for the routine dissemination of timely and comprehensive resource information.

Principal elements of the program include the development of space and supporting ground systems; improved data processing and analysis techniques; Shuttle and aircraft support for sensors and technique development; and basic and focused research for monitoring, analyzing, and modeling the vegetated and structural features of the Earth.

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LANDSAT-2 and LANDSAT-3, which was launched in March 1978, are operating and providing data routinely. LANDSAT-D is being developed and is on schedule for launch in 1981. In addition to continuing the availability of Multispectral Scanner (MSS) data, LANDSAT-D will provide imagery with the improved spectral and spatial resolution needed to expand the use of space data for agricultural, water resource and other applications.

Information on the Earth's geologic structure, chemical composition, and crustal processes is needed to improve the effectiveness of the exploration for new mineral and energy deposits. LANDSAT imagery has been very useful for this purpose, but is limited by its orbit and sensor characteristics. Therefore, several new information sources and techniques are being evaluated to assess their applicability for aiding in resource exploration. The Heat Capacity Mapping Mission was launched in 1978. Information from this mission is being used to discriminate rock types and soil compositions based on the thermal inertial characteristics of the material. In late 1979, the Magnetic Field Satellite (Magsat) will be launched to provide an up-to-date survey of the Earth's global magnetic field. These data are needed to produce magnetic field charts and maps for public use. In addition, the Magsat data will be used for studies of crustal inhomogeneities. Several experimental instruments are being developed to test the use of optical and microwave techniques for acquisition of geologic information. An imaging radar optimized to enhance the discrimination of terrain features and a microwave radiometer to differentiate among rock types and to determine surface composition are planned to fly on an early Shuttle mission. A Large Format Camera for precision mapping of large geographic areas and for studies of the use of stereographic imagery is planned for flight in 1980.

A major aspect of the Resource Observations Program is research associated with understanding and extracting the physical relationship of emitted and reflected radiation with vegetated and other surface features from remotely sensed data; with the development of models appropriate to the management of resources; and the evaluation of the use of space-derived data along with other data sources in meeting user needs. The scope of these activities ranges from individual scientific studies to projects such as the Large Area Crop Inventory Experiment (LACIE). Based on the results of the research, Application Pilot Tests are used to test and expand the research concepts in the realism of the users' environment. The LACIE, a cooperative effort with the U.S. Department of Agriculture (USDA), was completed in 1978. LACIE demonstrated the usefulness of space data in forecasting wheat production in the U.S. and abroad; it also identified areas where further research is needed. In FY 1980, a joint Agriculture Research Program will be initiated with the U.S. Department of Agriculture, the Department of Commerce (National Oceanic and Atmospheric Administration), Department of the Interior, and Agency for International Development to address priority information needs identified by the USDA. This will include a select group of crops and producing countries of significance to world trade and world nutrition. In FY 1980, three Application Pilot Tests will be completed: A wildland vegetation inventory with the Bureau of Land Management; a forest resource information system with the St. Regis Paper Company; and a land use and change detection effort with the U.S. Geological Survey. Other Application Pilot Tests will continue: An urban area boundary delineation project with the Bureau of the Census; an irrigated lands assessment for water management project with the State of California's Department of Water Resources, and a cotton crop inventory system project with Cotton, Incorporated. Two new pilot tests will be selected for

initiation in FY 1980. Candidates include a land productivity assessment with the Agency for International Development and a channel contour mapping test with the U.S. Army Corps of Engineers. In FY 1979, at the request of the Congress, studies were initiated to define the requirements for stereoscopic data for resource exploration and to develop technical and implementation approaches, as well as cost estimates. These system definitions for a future Stereosat mission will be completed in FY 1980.

The Geodynamics Program applies space observational techniques to studies of the solid Earth. These studies are expected to contribute to better understanding of the physical character and dynamic motions of the Earth and to mechanisms associated with catastrophic crustal movements. Major activities conducted under the Geodynamics Program include the development of improved models of the Earth's gravity field, and the development of techniques for the detection and measurement of tectonic plate motion and crustal deformation.

While the techniques and approaches used in these studies are unique, the questions addressed are fundamental problems in geophysics and geodesy. The solution to these problems is becoming more and more important because of population increases in seismically active areas of the United States and other parts of the world. In FY 1980, a joint program will be initiated with the U.S. Geological Survey, the National Science Foundation, the National Geodetic Survey, the Department of Defense and with other countries to begin to monitor the motion and internal stability of several major tectonic plates and to determine the crustal deformation in seismically active areas.

Earth Resources Technology Satellite (LANDSAT-D)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Spacecraft (multimission modular spacecraft)	15,000	20,000	20,000	6,000
Spacecraft systems and sensors	31,500	60,300	56,200	62,800
Ground data processing system	1,700	17,200	21,300	21,000
Total	48,200	97,500	97,500	89,800
Delta (expendable launch vehicles program)	(6,600)	(10,000)	(10,000)	(---)

OBJECTIVES AND STATUS:

The objective of the LANDSAT-D project is to continue the exploration of advanced research and development techniques for satellite-based Earth resources remote sensing systems with the experimental Thematic Mapper

and the flight-proven Multispectral Scanner. The initial LANDSAT-D launch is planned for late 1981; the backup spacecraft will be available for launch six months after the initial launch. The major technical focus of the LANDSAT-D project involves a test of both the Thematic Mapper instrument's capabilities and an improved ground data handling system. The Thematic Mapper--on which development was initiated in FY 1977--will offer higher resolving power and greater spectral coverage than existing instruments. These advantages promise to open up a significant number of new uses of LANDSAT data and to enhance many current uses.

The Multispectral Scanner (MSS) contract was awarded in March 1978. The design changes for the MSS which are required for the LANDSAT-D mission will be verified by tests during FY 1979 and the protoflight model fabrication will continue to support an early FY 1981 delivery to the mission contractor. A second MSS for the backup spacecraft has been added to the project to ensure that the initial and backup spacecraft have identical configurations. Development of the Thematic Mapper is on schedule for delivery to the mission contractor in October 1980. Design of the instrument is complete and integration of the engineering model is in progress. Systems testing of the engineering model is being initiated in FY 1979 and will be completed early in FY 1980.

Work is continuing on schedule for delivery of the systems modules of the Multimission Modular Spacecraft (MMS) to the MMS integration contractor in late FY 1979. The MMS integration contractor was selected during 1978. The LANDSAT-D mission contractor, responsible for development of mission-unique space hardware and the ground segment, was selected in late FY 1978. The contract also provides for the integration of the payload and the MMS. During FY 1979 design of the mission-unique items will be completed and fabrication initiated.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The current FY 1979 funding requirements for LANDSAT-D remain the same as the budget estimate. Adjustments between the project elements were based on detailed scheduling requirements.

BASIS OF FY 1980 ESTIMATE:

The Thematic Mapper engineering model testing will be completed and it will be delivered during early FY 1980. In addition, the fabrication and testing of the protoflight model will be completed and it will be delivered to the mission contractor in late 1980. The flight model fabrication and subassembly testing will also take place during FY 1980. In addition, the major elements of the protoflight Multispectral Scanner, such as the scan mirror assembly, radiometer and multiplexer, will be tested and integrated, and fabrication of the backup MSS for LANDSAT-D will be initiated. The MMS will be integrated and delivered to the LANDSAT-D mission contractor. Integration of the MMS and the LANDSAT-D mission-unique equipment, such as the solar array, tracking and data relay satellite system antenna and communications system, will be initiated. Design, procurement and fabrication of the ground system will be completed during FY 1980 and acceptance testing of the ground system will be initiated.

Magnetic Field Satellite (Magsat)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	8,908	3,220	3,220	460
Experiments	1,427	380	380	840
Ground operations	165	300	300	300
Total	10,500	3,900	3,900	1,600
Scout (expendable launch vehicle program)	(1,100)	(1,400)	(1,400)	(---)

OBJECTIVES AND STATUS:

The Magnetic Field Satellite (Magsat) Mission is designed to measure near-Earth magnetic fields on a global basis. The objectives are to obtain an accurate description of the Earth's magnetic field; to obtain data for use in the update and refinement of world and regional magnetic charts; to compile global crustal magnetic anomaly maps; and to interpret those maps in terms of geologic/geophysical models of the Earth's crust. The United States Geological Survey (USGS) plans to utilize the field models to update regional and global magnetic charts that they will issue in 1980. The USGS also plans to use the field models and the basic magnetometer measurements to derive magnetic anomaly maps for use in its natural resource assessment studies.

The spacecraft will be launched into a low Earth, near polar orbit by the Scout launch vehicle. The basic spacecraft is made up of two distinct parts: the instrument module, which contains a vector and a scalar magnetometer; and the base module which contains the necessary data handling, power, communications, command, and attitude control subsystems to support the instrument module. The base module with its subsystems is comprised primarily of residual Small Astronomy Satellite (SAS-C) hardware. The Applied Physics Laboratory of the Johns Hopkins University is developing the instrument module, with the exception of the magnetometers; building the base module; and serving as the integration and test contractor.

All major subcontract deliveries (i.e., instruments, tape recorders, transponders, star cameras) have been made. Mechanical integration of the base module and instrument module will be completed in January 1979. This will be followed by system tests and calibration. An Announcement of Opportunity was issued in September 1978 for scientific data analysis investigations. Selection of investigations is scheduled for mid-1979. The program is on schedule for a planned launch in late 1979.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 funds provide for post-launch support, spacecraft operations, and data analysis. This will include the processing and distribution of data, initial spacecraft orbit and attitude determination, and computation of the field models. Support will also be provided for the precision attitude determinations required to use the vector data for magnetic anomaly studies. The major activity will be the analyses conducted by selected Magsat principal investigators.

Shuttle/Spacelab Payload Development (Resource Observations)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Orbital flight test payload development	2,790	1,600	1,430	600
Large format camera	830	4,400	4,570	1,000
Total	3,620	6,000	6,000	1,600

OBJECTIVES AND STATUS:

The Space Transportation System will be used to test, demonstrate, and evaluate earth-viewing remote sensing instruments and systems and to obtain data for resource observations research. The objective of this project is to develop instruments which will fly on Shuttle orbital flight test missions and to develop a Large Format Camera to fly on Shuttle operational missions. The orbital flight test payload is under development. The instruments include: the Shuttle Imaging Radar (SIR-A) for all-weather identification of terrain features; a Shuttle Multispectral Infrared Radiometer (SMIRR) to conduct research for the optimum spectral bands for geological exploration; and an Ocean Color Scanner to assess the information which can be obtained from improved color sensing techniques in open ocean areas. The SIR-A will be the first use of spaceborne radar specifically for land form analysis. It is an adaption of the single frequency Seasat Synthetic Aperture Radar and will demonstrate the contributions an early radar system can make in resource observations. The Large Format Camera will have direct application to precision mapping of large geographic areas, and its stereo capability will be especially useful to mineral and petroleum resources exploration. A contract for the Large Format Camera development was signed with ITEK in 1978. A Large Format Camera Interagency Working Group was formed to support camera design and orbiter interface reviews; to evaluate pre-mission camera performance; to determine initial mission coverage requirements; to plan the investigations required to determine data utility; and to prepare post-flight data usefulness and system performance reports.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The total estimate for Shuttle/Spacelab payload development activities in FY 1979 remains the same as the FY 1979 budget estimate. The redistribution within the total reflects rephasing of requirements consistent with current flight plans.

BASIS OF FY 1980 ESTIMATE:

During FY 1980, the Resource Observations payload will be integrated into the Shuttle orbiter. The flight will be conducted, and data processing and analysis will be initiated. Development of the Large Format Camera will be completed, and it will be shipped to KSC for integration into the Spacelab pallet.

Extended Mission Operations (Resource Observations)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Heat capacity mapping mission (HCMM)	---	---	200	600
LANDSATS-2 and -3	200	---	150	900
Total	200	---	350	1,500

OBJECTIVES AND STATUS:

The objective of extended mission operations is to capitalize on the expected continued performance of the LANDSATS-2 and -3 and HCMM satellites beyond the planned mission duration. Data products from these missions are being used to support research activities in agriculture, water resources, geology and land use.

LANDSATS-2 and -3 were launched in January 1975 and March 1978, respectively. Operations for the LANDSAT missions as provided for in the LANDSAT-3 budget extend only to March 1980. LANDSATS-2 and -3 are major sources of space data for domestic and international users and essential elements of planned and continuing experimental demonstration activities.

The HCMM was launched in April 1978 and was planned for one year of operations. The mission provides thermal imagery which is being analyzed to assess the feasibility of using the thermal inertial characteristics of surface material to discriminate rock and soil types and for soil moisture studies.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

In FY 1979, funds were provided from Applied Research and Data Analysis to support continuation of services provided to LANDSAT users and to extend HCMM operations and data analysis support from April 1979 to October 1979.

BASIS OF THE FY 1980 ESTIMATE:

The FY 1980 funds provide for continuation of the LANDSAT-2 and -3 operations from March 1980 to October 1980 and for an additional year of HCMM operations. The LANDSAT data will be processed and provided to the U.S. Geological Survey's EROS Data Center for dissemination. The HCMM funds also provide for data processing and continuation of approved principal investigators' studies.

Geodynamics

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Crustal dynamics project	---	5,400	5,400	10,100
Modeling and technique development	6,940	3,200	2,800	3,000
Total	6,940	8,600	8,200	13,100

OBJECTIVES AND STATUS:

The goal of the Geodynamics Program is to use space technology to gain a more complete understanding of the dynamic processes occurring within and on the surface of the solid Earth. The nature of these processes, in terms of the evolution of the tectonic plates, and the forces that drive and deform the plates are fundamental problems in solid Earth sciences, with important implications for earthquake studies and resource exploration. Studies of geophysical phenomena such as the wandering of the Earth's polar axis and variations in the Earth's rotational rate are important because of suspected causative relationships with weather and climate, with mass motions internal to the Earth, and with mass redistribution within the Earth's upper layers. Mapping and modeling of the global gravity field provide information needed for understanding plate driving mechanisms, crustal processes associated with the formation of mineral and petroleum deposits, and for studies of oceanic circulation and current systems.

The objectives of the Crustal Dynamics project are to detect and monitor global tectonic plate motions to understand how and why the plates are moving; to determine if deformation internal to the plates is related to the unusual occurrence of major earthquakes away from plate boundaries; to map the accumulation of crustal strain in the vicinity of seismically active plate boundaries to understand how and where this energy is stored; and to observe the crustal motion prior to and after major earthquakes to understand how the accumulated energy is released. The results of this project are expected to contribute to the understanding of earthquake mechanisms and hence to the eventual development by other agencies of predictive techniques. The project will be conducted jointly with the USGS, NOAA, NSF, Defense Mapping Agency and, through international arrangements with other countries.

The principal measurement techniques for the crustal dynamics studies are laser ranging to satellites and very long baseline interferometry (VLBI), using signals from radio stars. During the past several years, measurement repeatabilities of ± 4 centimeters have been achieved for continental distances using fixed VLBI and to ± 6 centimeters over 500 kilometer distances using mobile VLBI. Work is continuing on identifying systematic biases in these techniques with the eventual goal of achieving measurement precisions of 1-2 centimeters. In mid-1979, we plan to deploy mobile lasers globally to range to the Laser Geodynamics Satellite (Lageos) for studies of polar motion, Earth rotation, solid Earth tides, and tectonic plate motion and deformation. Three of these lasers are now located at sites in the western U.S. to support continuation of the San Andreas Fault Experiment campaigns which were initiated in 1972. The Lageos data will be analyzed by Principal Investigators selected in response to an Announcement of Opportunity issued in October 1978. An experimental, highly mobile laser system, capable of visiting as many as twenty-five sites per year, is being completed by the University of Texas, Austin, under contract to NASA. The mobility and ranging performance of this Transportable Laser Ranging System (TLRS) will be tested later this year. In FY 1979, joint VLBI observations programs are planned with VLBI facilities in Sweden and West Germany. These experiments will be the first to measure the rate at which the North American and European continents are separating.

Also in FY 1979, NASA is assisting NOAA in converting radio antenna systems in Massachusetts, Florida and Texas to VLBI. These stations will form the basis for a NOAA polar motion and Earth rotation monitoring system which is scheduled to be operational in 1983. The Geodynamics Modeling and Technique Development Program supports studies of solid Earth dynamics, gravity and magnetic field modeling, geoid and magnetic anomaly mapping, and new system concepts. The principal objectives are to develop a better understanding of physical processes associated with crustal deformation mechanisms, polar motion, and Earth rotation, and to develop dynamic Earth models.

Progress with gravity field and geoid modeling has resulted in models which depict structural features such as deep ocean trenches and sea mounts, variations in ocean surface topography, and other gravitational variations associated with crustal densities. For studies of tectonic and crustal processes and oceanic circulation and currents, gravity field models accurate to a few hundred kilometers and several milligal are needed. Improvements to gravity field models are being sought through the use of satellite altimeter data. Studies are also underway to evaluate the need for a gravity field satellite to achieve the better accuracies.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The change in the FY 1979 funding reflects the transfer of topographic and magnetic mapping efforts from Geodynamics to Applied Research and Data Analysis.

BASIS OF FY 1980 ESTIMATE:

Beginning in FY 1980, the crustal dynamics studies will concentrate on the initiation of regional deformation studies in western North America and in the Caribbean, and on the establishment of baselines across active plate boundaries in several areas of the world. Mobile VLBI and laser ranging stations will be used to monitor, annually or semiannually, the vertical and horizontal displacement of points within a network of sites. Cooperative programs will be established with other countries to begin to study plate boundaries which are similar to or different from the San Andreas boundary to help elucidate the processes at the San Andreas boundary. Activities will also be initiated to monitor the motion and stability of the North American, Pacific and Australian plates and to expand the global plate measurement studies through cooperative arrangements with laser and VLBI facilities in other countries. In the modeling and technique development activity, FY 1980 funds will provide for the continuation of gravity field and geoid modeling as well as models of the motion of the solid Earth and of tectonic processes. Work will begin on formulating the basis for the eventual evolution of a global model of the dynamic Earth which will have broad application to basic science and to our understanding of geophysical processes.

Applied Research and Data Analysis (Resource Observations)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980
	(Thousands of Dollars)			
Renewable resources	16,200	16,100	17,950	23,000
Agriculture research enhancement	(---)	(---)	(---)	(3,400)
Non-renewable resources	3,045	2,000	2,700	3,600
Applications pilot tests	10,385	1,550	1,550	2,700
Operational Earth resources system (OERS) definition	---	---	---	3,000
Advanced studies	---	---	---	1,500
Total	29,630	19,650	22,200	33,800

OBJECTIVES AND STATUS:

The goal of this program is to develop remote sensing capabilities through theoretical studies, ground-based research and flight instrument development that can aid in the management of renewable and non-renewable resources and can monitor the impact of man and his works on the natural environment. Observables include surface characteristics such as type and extent of vegetation; characteristics of exposed soil and rocks; snow and ice cover, water improvements and soil moisture; geological structure and landforms; and the works of man such as urban and suburban developments, major facilities and surface mines. The program is closely coordinated with and in many instances developed in collaboration with other Federal agencies (such as the Department of Agriculture (USDA), Department of the Interior (DOI), Department of Commerce (DOC), Department of Defense (DOD), Federal Power Commission (FPC), and Agency for International Development (AID), state and local governments, and the private sector (e.g., the Geosat Committee)). This program supports the ground-based and the aircraft-based activities for Renewable and Non-Renewable Resource Observations research. The objectives of this effort are as follows: to improve machine-aided interpretation and classification techniques, data handling techniques, and data processing equipment, which are needed to increase efficiency in the transformation of space-derived data into information for utilization by the user community; to test this capability with the users through Applications Pilot Tests; to develop new sensors operating in the visible, infrared, and microwave regions of the spectrum, with emphasis on the latter two; to analyze user requirements for new types of space-acquired data; to develop and demonstrate ground-based or airborne systems that are derived from space technology, processes, management techniques or operations that contribute to the timely solution of natural resources problems. Through FY 1979, emphasis has been placed on developing techniques to interpret and use the visible and infrared data from LANDSATS 1-3, the limited amount of microwave data obtained from Seasat, the thermal data from HCMM, and aircraft data from visible, infrared, and microwave sensors. Studies are underway to develop capabilities to analyze and interpret the data which will be obtained by future systems, such as the seven channel, higher resolution data expected from LANDSAT-D, the multichannel data to be provided by the Shuttle Multispectral Infrared Radiometer (SMIRR), and the optimized look-angle radar data expected from the Spaceborne Imaging Radar (SIR-A).

In Renewable Resources, the major emphasis is on the new thrust in agriculture research. This six-year program is a joint undertaking of the Department of Agriculture, National Oceanographic and Atmospheric Administration, Agency for International Development, Department of the Interior and NASA. Techniques will be developed to use satellite remote sensing data to augment or replace existing sources of information, or to provide information not presently available, in the priority categories established by the Department of Agriculture. (Primary emphasis is placed on the first two items).

1. Early warning: develop meteorological parameters to indicate situations that will cause major changes in quality or production of a commodity. Landsat data will be used in checking and quantifying the event.

2. Commodity production forecasts: develop and test techniques for improving the quality and objectivity of foreign commodity forecasts.

3. Land use classification activities will improve domestic area determination at state and local levels and will develop techniques to monitor land use changes impacting agriculture.

4. Renewable Resource (forestry, range and wildlands): will support USDA/Forest Service in developing satellite remote sensing techniques for updating the periodic assessment required by the Resource Protection Act.

5. Land productivity: combined with land use activity to monitor and quantify impact of agricultural land use change.

6. Conservation: monitor the affect of conservation practices and water usage.

7. Pollution: monitor and quantify the pollution caused by agriculture practices and determine the effect of pollution on agriculture.

The results of this program will provide state-of-the-art analysis techniques to other research activities within Renewable Resources and will thus complement our existing on-going research activities with other agencies in land use and water resources.

CHANGES FROM FY 1979 ESTIMATE:

The increase in FY 1979 funding reflects in Renewable Resources the provisions for initial experimentation to develop production forecasting technology for corn and soybeans; and in Non-Renewable Resources, the provision for Stereosat definition studies and the transfer from the Geodynamics program of topographic and magnetic mapping activities.

BASIS OF FY 1980 ESTIMATE:

Renewable Resources: In FY 1980, in support of the Agriculture research effort, exploratory experiments based upon research activities conducted in FY 1979 and prior years will be conducted in the U.S. for wheat, barley, corn, and soybean; in India and Australia for wheat; and in the USSR for barley. In addition, supporting research activities will be initiated to improve quantitative estimating techniques for assessing crop, range land, and forest conditions.

Non-Renewable Resources: Principal efforts will be directed toward improving our ability to detect geologic structure and chemical composition and to understand geological processes, thereby enhancing exploration strategies for non-renewable resources. Included are empirical analyses of rock-type interpretation, structural mapping, and interpretation of regional magnetic and gravitational anomalies; development of exploration models; research on vegetation anomalies as indicators of mineralization; studies of the use of active and passive microwave for geologic structure mapping; and the initiation of definition studies for a polar orbiting satellite capable of obtaining global stereo data.

Application Pilot Tests: FY 1980 funds will support seven Application Pilot Tests (APT), five on-going with the Bureau of the Census, California Department of Water Resources, U.S. Forest Service, Cotton Inc., and the St. Regis Paper Company., and two new APT's will be initiated with the Agency for International Development and the U.S. Army Corps of Engineers.

In FY 1980, OERS definition funds will be used to integrate data acquisition requirements with system engineering parameters. Conceptual designs of space and ground systems will be developed and implementation options will be analyzed. Economic and institutional studies will be performed to support pricing policies and private sector involvement. This work will be performed in collaboration with an interagency working group.

Advanced studies in FY 1980 will be performed on a variety of sensors and missions including Multispectral Resource Sampler, Stereosat, Soil Moisture Monitoring Mission, and Earth Resources Synthetic Aperture Radar.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

ENVIRONMENTAL OBSERVATIONS PROGRAM

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Tiros-N	4,100	---	1,200	---	7-23
Nimbus-7	12,210	2,800	3,624	500	7-24
Seasat	14,367	3,000	3,500	---	7-25
Earth radiation budget experiment	---	8,000	7,000	23,000	7-26
Halogen occulation experiment	---	6,100	3,600	8,000	7-28
Stratospheric aerosol and gas experiment	2,400	---	---	---	---
Shuttle/Spacelab payload development	6,040	7,300	7,750	7,400	7-29
Operational satellite improvement program	5,600	6,100	6,100	7,400	7-31
Applied research and data analysis	29,298	31,800	33,876	49,900	7-32
Extended mission operations	1,400	2,500	1,250	5,800	7-35
Upper atmospheric research	(12,080)*	(14,500)*	(14,500)*	15,200	7-36
Total	75,415	67,600	67,900	117,200	

OBJECTIVES AND STATUS:

Understanding the dynamics and limitations of our environment is essential to our long term survival. The objectives of NASA's Environmental Observations Program are to improve our understanding of processes in the atmosphere and oceans, to provide space observation of parameters involved in these processes, and to extend the capabilities to predict environmental phenomena and their interaction with human activities. The interactions among the processes and the interrelationship of the atmosphere, ocean, land and space environments can only be fully studied on a global basis from space. NASA's program includes research efforts plus the development, demonstration and transfer of new technology for global and synoptic measurements. It also includes the use of research satellites for the study of the radiative, chemical, and dynamic processes occurring in the atmosphere and oceans.

*Program transferred from Space Science to Space Applications in January 1979; FY 1979 and prior funding not included in total.

Inasmuch as the physical and chemical processes in any one layer of atmosphere or oceans must be understood in relation to the other layers, NASA has recently combined all of its atmospheric and oceanic studies by transferring the responsibility for the Upper Atmosphere Research Program from the Office of Space Science to the Office of Space and Terrestrial Applications. This transfer will help to assure an integrated NASA atmospheric program, strengthen the Environmental Observations Program, and provide for the maximum interchange of information in the atmospheric research community.

The Environmental Observations Program now includes studies of all the layers of the atmosphere, from the turbopause (100-110 km) down to and including the upper layers of the oceans, and the full range of geographical perspectives, from the local scale to regional and global scales. The program areas include: (1) upper atmospheric research, (2) global weather, (3) severe storms, (4) climate, (5) environmental quality (including stratospheric pollution and tropospheric pollution), and (6) oceanic processes (including water pollution, ocean dynamics, ice dynamics, and coastal processes). This integrated approach encompasses the diverse fields of meteorology, climatology, atmospheric chemistry, atmospheric physics, and oceanography, and focuses on the special contribution of space derived data. In support of these programs, four spacecraft were launched in 1978--SEASAT, Tiros-N, GOES-3, and Nimbus-7. The Stratospheric Aerosol and Gas Experiment will be launched in 1979, the Halogen Occultation Experiment in 1982 and 1983, and the Earth Radiation Budget Experiment instrumentation on two National Oceanic and Atmospheric Administration (NOAA) meteorological and a NASA dedicated spacecraft during 1982-1984. Valuable research data will also be obtained from experiments to be conducted on Spacelab missions, such as the Atmospheric Cloud Physics Laboratory, and from the Office of Space Science's Solar Mesopheric Explorer.

On a local scale, NASA's program aims at aiding the mission agencies to improve the accuracy of severe storm forecasts and at measuring urban pollution episodes from space. Frost and freeze warnings are one example of the former. NASA field experiments in the southeastern Virginia region demonstrate the utility of NASA sensors for regional air pollution studies. NASA and the Environmental Protection Agency (EPA) have initiated an effort to develop a cooperative plan to demonstrate synoptic coverage of regional air pollution.

In FY 1980, NASA's severe storm research will include analytical studies to improve the basic understanding of storms, the use of storm observations in forecast models, and development of sensors based on the Doppler shifts of reflected radiation. The program will emphasize energy exchanges and fluid flow around storms.

On a regional scale, the Environmental Observations Program addresses: (1) pollution transport in air and water; (2) coastal and cryospheric processes; (3) tracking ocean currents; (4) determining exchange mechanisms of stratospheric and tropospheric air; and, (5) improving remote sensing for synoptic weather forecasts.

In FY 1980, NASA's air quality research will focus on regional tropospheric chemistry, transport dynamics, and possible prediction techniques for air pollution episodes. Also, interhemispheric variations of tropospheric carbon monoxide will be measured from space. An important 1980 thrust is the simultaneous measurement of key species in the chlorine, nitrogen, and hydrogen chemistry families.

The NASA climate effort, in support of the National Climate Program, will emphasize those long-term global measurements and research areas involving atmospheric and oceanic phenomena where space systems can provide a significant contribution to achieving a better understanding of climatological processes.

To provide improved observing systems for the operational meteorological satellite missions, NASA's global weather activities include: support to the GARP Global Weather Experiment; development of improved operational meteorological satellite systems; research into modeling using satellite data; development of improved sensors, improvement of techniques to extract meteorological parameters from remotely sensed data; and conduct of experiments in space.

To achieve maximum utilization of remote observations, NASA will perform numerical sensitivity studies of possible future remote measurements. FY 1980 will see the continuing research toward an advanced meteorological temperature sounder, development of a laser atmospheric profiler, and exploration of wind measurement techniques from space platforms.

NASA and the oceanographic science community have begun to realize the tremendous power that satellites can bring to the study of the world's oceans. The first dedicated oceanographic satellite--SEASAT--was launched in June of 1978. The observations collected during 99 days of successful operation are an important data base which will be analyzed thoroughly by the end of FY 1980. Increased participation by the oceanographers in NASA's program will be supported by numerous activities in FY 1980, such as: (1) a real-time satellite station at the Scripps Institute of Oceanography; (2) large scale oceanic models; (3) joint experiments involving remote observations of the sea surface; (4) ice dynamic studies; and, (5) ocean circulation studies.

In FY 1979 and FY 1980, NASA, NOAA and the DOD are studying the programmatic and technical requirements for a National Oceanic Satellite System (NOSS), which would have the objective of demonstrating, on a limited operational basis, the capability for remote sensing from space to obtain data on such oceanic features as directional wind stress, sea surface topography, ice cap profiles, significant wave height, directional wave spectra, sea ice patters, internal waves, sea surface temperature, and chlorophyll.

In 1980, models of air-sea interactions will be developed and the influence of sea-state on the backscatter of electromagnetic signals will be investigated. Ice dynamics models will be developed to accommodate remote sensor data, and surface truth experiments will improve understanding of microwave sensors for ice. Analyses of coastal phenomena will provide biomass distributions, concentrations, and variations using data from the Nimbus-7 Coastal Zone Color Scanner (CZCS).

The near-term emphasis of NASA climate research is on the design and development of the Earth Radiation Budget Experiment (ERBE). We will continue measurement of the solar constant with Nimbus-6, Nimbus-7, Solar Maximum Mission, Spacelab-1, ERBE, and several sounding rocket calibration flights.

In FY 1980, five areas will be considered for special analytic studies: (1) cloudiness and radiation budget; (2) air/sea interactions; (3) cryospheric processes; (4) hydrological processes; and (5) sun-weather relationships. In addition, studies will be continued on new sensors for precipitation, clouds, and ice. Numerical sensitivity studies will determine the most effective distribution for observations and the most important parameters to be measured. Satellite data sets on the Earth and solar radiation, ozone concentration, rainfall and sea ice will be extended.

In summary, the NASA major near-term thrusts in Environmental Observations are to: (1) understand the physics and chemistry of the atmosphere; (2) detect any global changes in stratospheric ozone; (3) improve measurements of atmospheric temperature, moisture, pressures, winds, and precipitation; (4) utilize Global Weather Experiment data to test models and study error sources; (5) validate severe storm indicators and precursors; (6) analyze satellite data to validate photochemical transport models of the atmosphere (especially the troposphere); (7) study the possibilities for a joint NOAA, NASA and DOD demonstration of an operational system for ocean monitoring; (8) analyze Seasat data for oceanographic information; (9) determine the dynamic behavior of water and ice (coastal zone and deep ocean); (10) carry out special studies of climatic processes, (i.e., aerosols and radiation budget); and, (11) perform sensitivity analyses on other climate observables (cryosphere, air/sea interactions, precipitation, etc.). Together, these comprise NASA's applications of space observations to the understanding and prediction of the behavior of the fluids (air and water) which make up our planet's dynamic environment.

Operational Temperature Sounding Satellite (TIROS-N)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Spacecraft and support	3,759	---	1,079	---
Sensor development	34	---	---	---
Ground operations	307	---	121	---
Total	4,100	---	1,200	---
Atlas-F (expendable launch vehicles program)	(2,700)	(---)	(---)	(---)

OBJECTIVES AND STATUS:

The objective of the TIROS-N project is to develop a prototype satellite and sensors capable of meeting stated future requirements of the National Oceanic and Atmospheric Administration (NOAA) for obtaining

quantitative data of the Earth's atmosphere on a daily basis. TIROS-N was successfully launched on October 13, 1978. The data are being used in numerical models of the Earth's atmosphere whose solutions are expected to significantly improve long-range weather predictions. The payload consists of six sensors: a High Resolution Infrared Sounder is measuring the temperature and moisture profiles at several altitudes in the troposphere and lower stratosphere; a Stratospheric Sounding Unit, provided by the United Kingdom at its own expense, is providing similar data in the upper stratosphere; a Microwave Sounding Unit is obtaining atmospheric temperature measurements even in the presence of clouds; the Advanced Very High Resolution Radiometer is providing detailed cloud images as well as sea-surface and cloud-top temperatures for use in improving the accuracy of 12-to-36 hour weather forecasts; a Data Collection System, furnished by France at its own expense, is gathering environmental data from remote platforms located throughout the world; and finally, a Space Environment Monitor is making daily observations of electron, proton, and X-ray activity in the near-Earth space environment.

CHANGES FROM 1979 BUDGET ESTIMATE:

The increase in the FY 1979 budget estimate is due to the TIROS-N launch delay from May until October, which resulted from launch pad conflicts and technical problems with the spacecraft.

Air Pollution and Oceanographic Observing Satellite (Nimbus-7)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Spacecraft	3,700	600	---	---
Sensors and data analysis	4,610	1,330	2,324	---
Ground support	3,900	870	1,300	500
Total	12,210	2,800	3,624	500

OBJECTIVES AND STATUS:

The detection and measurement of atmospheric and water pollution constituents on a global basis require the collection of remotely-sensed repetitive data from space. The Nimbus-7 spacecraft, successfully launched in October 1978, provides this capability on this scale for the first time.

Four of the spacecraft sensors detect and measure constituents related to atmospheric pollution, specifically constituent gases and particulates. Taken on a global basis, these measurements will be used to analyze pollutant concentrations and movements to determine their sources and life cycles.

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Two other sensors will be used to obtain high spatial resolution ocean color measurements near the coastlines (relating to nutrients, pollutants, and salinity) and microwave measurements of the ocean/atmosphere interface characteristics. The data is useful in applications such as ocean-food investigations and survey of ocean pollution as well as knowledge of the interactions between the ocean, the atmosphere, and the Sun.

The remaining spacecraft sensor is continuing the collection of data pertaining to the Earth's radiation budget begun on earlier Nimbus spacecraft. This effort extends the long-term baseline of data leading to a better understanding of the Earth's thermal balance.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The Nimbus-7 launch was delayed from August to October 1978 based on launch facility availability and technical problems with the spacecraft tape recorder. Some effort originally planned for FY 1978 was therefore deferred into FY 1979.

BASIS OF FY 1980 ESTIMATE:

The delayed launch will result in the last month of the baseline Nimbus-7 project mission operations occurring in FY 1980. Funds requested in FY 1980 will support mission operations for that month.

Ocean Dynamics Satellite (SEASAT)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Spacecraft and support	9,106	---	---	---
Sensor development	1,720	---	---	---
Mission operations	3,541	3,000	3,500	---
Total	14,367	3,000	3,500	---
Atlas-F (expendable launch vehicles programs)	(3,600)	(---)	(---)	(---)

OBJECTIVES AND STATUS:

The objective of the Ocean Dynamics Satellite, SEASAT, is to provide a proof-of-concept demonstration for the use of satellite-acquired data for the detection, monitoring, and forecasting of ocean conditions. Specific

applications being explored are the use of data on wave height, wind direction and speed, and sea surface temperature for improved forecasting of ocean conditions for ship routing, fisheries management, off-shore gas and mining operations, and for synoptic improvements in short range global weather forecasting.

SEASAT-1 was successfully launched from the Western Test Range at Vandenburg Air Force Base on June 26, 1978. After 106 days in orbit, a massive power failure resulted in loss of all onboard data and effectively terminated the spacecraft mission. However, during the 106 days, two major surface truth support activities were conducted, thus significantly enhancing the value of the SEASAT data set. The SEASAT data set is currently being analyzed; the assessment at this time is that the major part of the project's objectives will be satisfactorily accomplished.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The increase in the FY 1979 budget estimate is primarily due to the support of analysis activities associated with the SEASAT Mission Failure Investigation Board.

Earth Radiation Budget Experiment

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	---	4,600	3,400	10,700
Sensors	---	3,400	3,300	11,800
Mission operations and data analysis	---	---	300	500
Total	---	8,000	7,000	23,000

OBJECTIVES AND STATUS:

More solar energy is absorbed by some regions of the Earth than by others. At the same time, more thermal energy is radiated into space by some regions than others. This differential heating is thought to be the driving force that sets the atmospheric winds and ocean currents into motion so as to transfer heat from warmer areas to cooler areas. The excess in the amount of solar energy absorbed over the thermal energy radiated to space continually changes for any given region, depending on the time of year, degree of cloudiness, snow and ice cover, atmospheric dust and aerosols, and properties and conditions of the surface.

The objective of the Earth Radiation Budget Experiment is to measure the temporal and spatial variations in the radiation balance over the globe. General agreement exists within the scientific community that the Earth's radiation budget must be monitored from space if we are to gain basic insights as to reasons for climatic fluctuations.

Experimental Earth radiation budget instruments have flown on the Nimbus satellites, and sampling studies based on those experiments have shown that adequate global coverage requires a multiple satellite system. They also indicate the need for more stringent calibration of the sensors. Two NOAA satellites of the Tiros-N series will be flown in sun-synchronous orbits equipped with identical Earth Radiation Budget instruments. One of the NOAA satellites will have a morning equatorial passage time, while the other will have a mid-afternoon passage time. Adequate mid-latitude and equatorial coverage requires an additional satellite. Therefore, a third set of instruments will be flown on a NASA dedicated spacecraft in a 46° inclined orbit plane. Each equatorial region must be viewed at least once each month at each hour of the day, and the orbit altitudes and instrument view angles must be known to permit geographical location of the radiometer footprints. Together, the three satellites will provide accurate measurements of the monthly average radiation balance with regional, zonal, and global resolutions. The planned launch dates are 1982-1984 for the NOAA satellites and 1983 for the NASA dedicated satellite.

The scientific objectives and measurement requirements have been developed by a joint NOAA/NASA team of scientists that included leading scientists from the university community and other non-Government organizations. These requirements have been reviewed by a committee of the National Academy of Science. During FY 1979 the ERBE instrument specification and associated Request for Proposal package was released to potential contractors; selection of the contractor is scheduled for June 1979. Engineering design of the instruments is in process. Design modifications to accommodate the ERBE instruments on Tiros-N/NOAA spacecraft bus will be accomplished and the contract for the NASA dedicated spacecraft bus and Shuttle interface will be negotiated. Data processing algorithms are being defined by the ERBE experiment team.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

Total estimated funding for ERBE remains the same but $1 million was rephased from FY 1979 to FY 1980 based on better estimates of the project needs for the modification of the Tiros-N/NOAA spacecraft and for the instrument contract.

BASIS OF THE FY 1980 ESTIMATE:

FY 1980 funding will be used to complete the major portion of the Tiros-N/NOAA spacecraft modifications to accommodate the ERBE instrument, to continue the design and development of the ERBE instruments, and to support the initial fabrication of the NASA dedicated spacecraft plus the design of the Shuttle/spacecraft interface hardware. ERBE experiment team members are scheduled to be selected by mid-year and funding support for data processing, algorithms and model software effort for the team will be provided.

Halogen Occultation Experiment

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Sensor development	---	6,100	3,600	8,000

OBJECTIVES AND STATUS:

The Halogen Occultation Experiment (HALOE) will provide global stratospheric vertical concentration profiles of key chemical species involved in the catalytic destruction of ozone due to chlorine compounds. These measurements will assist in estimating the depletion of stratospheric ozone due to natural and man-made causes involving chlorofluoromethanes (CFM's). Specific objectives of HALOE are: (1) to monitor globally the vertical profiles of concentrations of stratospheric hydrogen chloride, hydrogen fluoride, and water and other trace gases of importance to the chlorine chemistry; and (2) to use the measured data (a) in obtaining horizontal and vertical maps of gas concentrations; (b) in performing a chlorine source analysis; (c) in validation of chemical and dynamic models describing the effects of CFM's on the ozone layer; and (d) in predicting ozone depletion and depletion rate due to chlorine build-up in the stratosphere.

An initial test of the engineering model instrument is being planned for flight on a Shuttle mission to demonstrate the validity of the measurement technique in a space environment and to evaluate the instrument operating parameters. A longer duration mission of one to two years will take place on the Earth Radiation Budget Experiment mission in 1983. Conceptual design of the HALOE instrument has been accomplished under the Advanced Applications Flight Experiments (AAFE) program. Design of the spaceflight instrument is in progress, with fabrication scheduled to begin in July 1979.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

Earlier estimates were based on plans for two flights of this instrument on short-duration Shuttle missions. Due to adjustments in the Shuttle launch schedule and a re-evaluation of the need for two HALOE checkout flights, only one Shuttle flight of the HALOE is planned prior to the Earth Radiation Budget Experiment mission. The project funding has been revised consistent with this plan.

BASIS FOR FY 1980 ESTIMATE:

In 1980, fabrication of the engineering model unit to be flown on the Shuttle will continue, leading to delivery of the instrument for integration in mid-1981. Detailed design of major subsystems of the flight unit for the Earth Radiation Budget Experiment will also be supported with FY 1980 funds. Science activities will be focused on modeling techniques and development of the inversion algorithms.

Shuttle/Spacelab Payload Development (Environmental Observations)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Measurement of air pollutants from satellites (MAPS)..	740	600	500	800
Atmospheric trace molecules observed by spectroscopy (ATMOS).....	2,600	2,300	3,750	3,200
Atmospheric cloud physics laboratory (ACPL).....	2,700	4,400	3,500	3,400
Total.....	6,040	7,300	7,750	7,400

OBJECTIVES AND STATUS:

The Space Transportation System offers the opportunity for frequent, short-duration flights for instruments and associated experiments. The Environmental Observations Program is incorporating this new capability in order to capitalize on three important facets: (1) early tests, checkout and design refinement of remote sensing instruments whose ultimate use is in a long-duration monitoring system on a free-flying satellite; (2) short-term data gathering of atmospheric and environmental processes for basic research and analysis where long-term observation is not necessary or is impractical; and (3) research into processes which cannot be accomplished effectively in ground-based laboratories because of the effects of gravity. The three efforts presently under development are: Measurement of Air Pollutants from Satellites (MAPS); Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS); and Atmospheric Cloud Physics Laboratory (ACPL).

Measurement of Air Pollutants from Satellites (MAPS) -- This experiment, selected for the payload complement for the first Office of Space and Terrestrial Applications (OSTA) mission on the Shuttle, will be the first test of using gas filter correlation radiometry for tropospheric measurements from orbit. Mid- and upper-tropospheric carbon monoxide will be measured and will be used as a tracer to observe and define the extent of interhemispheric mass transport in the lower atmosphere. Results will be used by researchers to: (1) test the accuracy of photochemical model calculations; (2) evaluate the relative magnitude of natural and man-made carbon monoxide sources; and (3) refine current estimates of interhemispheric mass exchange.

The instrument itself is derived from a brass-board model originally developed as a candidate for the Nimbus-7 mission. It was subsequently modified for aircraft experimentation and has been used successfully in this mode to map pollution plumes in industrial areas. The instrument for the Orbital Flight Tests is scheduled for delivery to Langley Research Center in early 1979 for calibration and instrument characteristics testing. The integration testing will begin in 1979 leading to a launch in mid-1980.

Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS) -- The objective of this investigation is to make detailed measurements of gaseous constituents in the Earth's upper atmosphere using the techniques of infrared absorption spectroscopy. Specific constituents to be measured are hydrogen chloride, water, ammonia, methane, nitrous oxide, deuterium oxide, and ozone. These data will allow the determination of the compositional structure of the upper atmosphere, including the ozone layer, and its spatial variability on a global scale. The high resolution, calibrated spectral information will also be utilized for design criteria for future instruments whose objective is to monitor a specific constituent on a long-term basis.

Early versions of this high speed interferomter have been tested in the laboratory, on balloon flights, and on aircraft. With the selection of this experiment for flight on Spacelab 1, a contract was signed in late 1977. The preliminary design review has been held and the project is proceeding on a schedule compatible with the planned Spacelab 1 mission.

Atmospheric Cloud Physics Laboratory (ACPL) -- The objective is to perform research into the very small-scale (microphysical) atmospheric cloud processes. Experimentation in Earth-based laboratories related to processes that occur inside the clouds is very difficult because gravity-driven convection and droplet setting begin immediately after a cloud is formed. This makes observation of the critical droplet-forming stage nearly impossible on Earth. This program will provide a unique, multipurpose laboratory facility for flight in the habitable Spacelab module to achieve a low-gravity environment for experimentation. In orbit, experiments will be performed by a payload specialist in close coordination with the ground-based investigators. Formation of clouds under these conditions will allow measurement of their properties over relatively long periods of time.

The objectives of the first (ACPL-1) flight will be to validate and establish baseline system characteristics, to investigate the microphysics of warm cloud processes, and to observe ice crystal growth in zero gravity under carefully controlled conditions. The Preliminary Design Review was held in mid-1978. All major subcontracts have been let, the engineering model components are on order, and detailed design of the system is in progress. A preliminary design review of the ACPL-1 experiments has been completed and special requirements factored into the baseline design.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

Measurement of Air Pollutants from Satellites -- The decrease resulted from a rephasing of funding requirements.

Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS) -- The original concept for mounting this instrument was inside the Spacelab habitable model. Due to the design and operational complexity associated with this configuration and the restricted opportunities for re-flight in this mode, a decision has been made to design the instrument for pallet mounting.

Atmospheric Cloud Physics Laboratory (ACPL) -- Consistent with the planned Schuttle schedule, the initial flight of the ACPL will take place later than anticipated. The activities to modify the laboratory experiments to investigate the formation of ice clouds during expansions of moist air will be postponed.

BASIS OF FY 1980 ESTIMATE:

Measurement of Air Pollutants from Satellites (MAPS) -- The FY 1980 activities will be focused on support to the launch and mission operations activities and initial data analysis. Real time support will be required for the integration process and flight operations. Data analysis and involvement of the principal investigator team will begin within one month after completion of the mission.

Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS) -- Delivery of the instrument from the contractor is scheduled for early 1980. In the period just prior to delivery, the final system integration will occur and the instrument performance and environmental testing will be accomplished. After receipt at JPL, an internal verification and familiarization program will be performed by the experiment team to establish baseline characteristics of the instrument. The software for data analysis will be generated and validated during this time period. Delivery of the instrument for integration into the Shuttle payload is scheduled for late 1980.

Atmospheric Cloud Physics Laboratory (ACPL) -- During FY 1980, the laboratory critical design review will be completed and development testing of the engineering unit accomplished. Payload specialist training will be conducted at the prime contractor's plant on the engineering unit hardware. The principal investigators (PI's) for the first flight of ACPL will conduct experiment testing on the laboratory compatibility. The engineering unit hardware will be refurbished and qualification tests will be conducted. PI's selected for research in cold-cloud processes will continue experiment development under previously initiated contracts.

Operational Satellite Improvement Program (OSIP)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Research and development for improvement of operational satellite systems.....	5,600	6,100	6,100	7,400

OBJECTIVES AND STATUS:

The objective of the operational satellite improvement program is to carry out the research and development activities which will provide advanced sensors, spacecraft subsystems, and ground equipment for present and future operational satellite systems.

Current developments include modifications of the Advanced Very High Resolution Radiometer to add a fifth channel for improved sea surface temperature measurements; modification of the Nimbus High Resolution Infrared Sounder for flight on NOAA operational spacecraft; modification of the Nimbus Solar Backscatter Ultraviolet (SBUV) instrument for monitoring changes in global ozone; and the development of the VISSR Atmospheric Sounder for obtaining temperature profiles from geostationary orbit. All of these developments are nearing completion; the sensors are scheduled for flight between now and late 1982.

BASIS FOR FY 1980 ESTIMATE:

FY 1980 funds will be used to complete development effort on the VISSR Atmospheric Sounder for flight on GOES-D, which is now scheduled for launch in mid-1980. In addition, work will continue on modifications to the Nimbus SBUV to be used as an ozone monitor in the NOAA operational satellite system beginning in the 1982-83 time period. Effort will also be initiated in defining spacecraft, instruments, and ground systems applicable to meeting the needs of the operational system in shifting over to the Shuttle mode of operations in the 1985 time period.

Applied Research and Data Analysis (Environmental Observations)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Applied research and data analysis in:				
Global weather (including GARP)	8,300	8,600	8,500	10,700
Climate	2,500	4,200	4,200	8,500
Severe storms	3,500	3,700	3,700	5,200
Environmental quality	9,200	8,400	8,400	11,100
Ocean processes	5,798	6,900	7,576	11,400
System 85 definition	---	---	---	1,500
National oceanic satellite system (NOSS) definition	---	---	1,500	1,500
Total	29,298	31,800	33,876	49,900

OBJECTIVES AND STATUS:

The objectives of this program are to improve our understanding of atmospheric and oceanic processes in order to extend our capabilities to predict environmental phenomena and their interaction with human activities. This includes research and the development, demonstration and transfer of new technology in the area of space systems capable of making global and/or synoptic measurements of the atmosphere on an operational basis. It also includes the development and use of research satellites to provide unique perspective of space for the study of the radiative, chemical and dynamic processes occuring in the atmosphere and oceans, the interactions among these processes, and the interrelation of the atmosphere, ocean, land and space environments.

The scope of the program varies from the small spatial and temporal scales of severe local storms and urban pollution episodes to the global spatial scale and long-time scales of climate. Our integrated program permits a focus on the interrelationship between the classically diverse fields of meteorology, climatology, atmospheric chemistry, atmospheric physics and oceanography, as well as individually upon these disciplines themselves.

On short time scales, the program aims at localizing and improving the accuracy of severe storm forecasts and warnings, and at developing the capability to measure and characterize severe weather and urban pollution episodes from space. On a regional scale we are addressing concerns with the transport of pollution in the air and water, coastal and cryospheric processes, tracking the fluctuations in major ocean currents, determining the mechanisms for exchanges of stratospheric and tropospheric air and improving synoptic weather forecasts through better remote sensing techniques.

Capitalizing on the global perspective of space, the program objectives are to study tropospheric and stratospheric pollution, to measure the radiative budget of our planet, to improve numerical weather prediction, to determine the morphology of lightning and severe storm occurrence, and to develop and demonstrate the capability for remotely sensing ocean surface properties, the air-sea interface, and the distribution of biomass in the uppermost layer of the ocean. The climate element of the program takes a long term perspective of the phenomena of the atmosphere and ocean with the objective of determining, interpreting, and obtaining those global data sets from spaceborne platforms which, in cooperation with other related programs, will provide a long term predictive capability.

To a varying extent, each of the elements of the program supports the development and demonstrations of remote sensing technology, the development of algorithms to extract geophysical parameters from remote data, suborbital and ground based experiments to measure fundamental properties and processes of the system and provide a base for remote sensor development, fundamental research into the processes at work in the environment and the development of models which express the current understanding of all or part of this system and provide a predictive capability.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

Funding in FY 1979 has been increased by approximately $2 million to provide for more timely, in-depth analysis of data obtained from SEASAT, and to support preliminary definition activities for the National Oceanic Satellite System.

BASIS FOR FY 1980 ESTIMATE:

NASA has successfully orbited the Tiros-N satellite which is essential to the gathering of atmospheric and oceanic observations for the First GARP Global Weather Experiment (FGGE) covering a one-year period which commenced December 1, 1978. NASA, NSF, NOAA and others are participating in FGGE. NASA will support numerous data analysis experiments and extended meteorological soundings. Research will be supported for wind and improved temperature measurements from remote platforms. NASA will also undertake an enhanced research effort to develop microwave pressure measurements and develop technology for advanced sensor concepts, algorithm and data processing techniques.

In the climate area, NASA will conduct special studies of climate processes with emphasis on the Earth's radiation budget and aerosol effects. Data sets related to these studies will be developed and NASA's climate modeling capabilities will be expanded in order to perform the necessary sensitivity studies of climate parameters. Data sets will be developed, and analytical studies will be carried out on precipitation and air/sea interactions and their contributions to climate. New sensors for remote measurements of clouds, precipitation and ice will be investigated and simulations for future global observational systems will be performed.

Analytical studies on severe storms will permit the best analysis of observation data and evaluation of severe storms forecast models. A doppler sensor for wind field observations will be developed and studies conducted on storm precursors. Studies will be performed in an attempt to understand the basic energy exchanges, fluid flow configurations and to determine if there are any ionospheric indicators or precursors to severe storms.

In the environmental quality area, studies will be continued on ozone climatology, global atmospheric chemical cycles, circulation and diffusion in water, and regional tropospheric dynamics. Rocket and balloon ground truth measurements will be provided for the Nimbus-7 and Stratospheric Aerosol, and Gas Experiment and the data investigations conducted for these extended missions. Improved limb scanning, gas filter correlation, and multi-spectral remote sensors will be investigated. Technology improvements will be pursued in active laser and microwave techniques for direct and remote measurements in the troposphere and stratosphere.

Studies of oceanic processes will include micro-scale and meso-scale surface and subsurface dynamics, ice dynamics, ocean circulation and topography and improved data processing techniques. Follow-on investigations

will be supported on the existing SEASAT data. Mission planning studies will be performed on coastal zone observations and the cryosphere. Research will be conducted on advanced microwave sensors for improved water and ice observations. Advanced studies with NOAA and DOD for future research and operational ocean related missions will continue.

FY 1980 funds will also provide for definition studies of the next generation meteorological satellite systems (Systems 85) and a continuation of the interagency studies of the programmatic and technical requirements for a National Oceanic Satellite System. These studies will include instrument definition and overall systems requirements definition.

Extended Missions Operations (Environmental Observations)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Operations for the extended missions of:				
Nimbus 5-7	900	---	---	5,200
Stratospheric aerosol and gas experiment	---	---	700	600
Geodynamic experimental ocean satellite	500	500	550	---
SEASAT	---	2,000	---	---
Total	1,400	2,500	1,250	5,800

OBJECTIVES AND STATUS:

Nimbus-7 was launched in October 1978. Extending the mission through FY 1980 will provide unprecedented baseline atmospheric and surface data. Data which has been only initially analyzed can yield vital information when additional analyses and user investigations are performed and additional corroborative data are collected. Urgent needs continue for these data which include, among others, global precipitation, soil moisture, and snow-and-ice-cover data from the microwave sensors from Nimbus-5, -6, and -7, and important data on the Earth's radiation budget from both Nimbus-6 and -7. These data, when properly reduced to useful physical parameters and furnished to the scientific and data-user community in practical forms are expected to be applied directly to specific national and global problems. Such problems include the trend of regional and world weather, severe storm analysis and prediction, and numerical forecast model improvements. The satellite carrying the Stratospheric Aerosol and Gas Experiment (SAGE) instrument, to be launched in early 1979, will provide for essentially global monitoring of ozone and aerosols by solar occultation means.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease in the FY 1979 SEASAT budget estimate results primarily from the failure of the SEASAT spacecraft after 106 days of successful in-orbit operation, 99 of which were data-collecting days. The funding originally planned for extended operations will be used for SEASAT data utiliztion which is conducted within the Applied Research and Data Analysis area. The increase for SAGE is for support and to provide an additional six months of mission operations, data processing and data analysis in order to provide one full year of mission support. The increase for the Geodynamic Experimental Ocean Satellite results from the consolidation of science support for the mission.

BASIS OF FY 1980 ESTIMATE:

This funding will provide for continuing Nimbus-7 space flight operations, data collection, processing and formatting into user products, and distribution, and for continuing Nimbus-5 and -6 operations. By extending the SAGE mission through the winter of FY 1980, a second set of winter transport data will be obtained, which will aid in the longer range evaluation of the effects of man-made and natural effluents on the ozone and the contribution of aerosols to ozone depletion. The funding requested will also support the selected investigators in furthering their analyses of the data.

Upper Atmospheric Research

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Research support	(11,600)	(11,900)	(11,900)	11,400
Upper atmospheric research balloon program	(160)	(1,000)	(1,000)	1,100
Spacelab payload definition	(320)	(600)	(600)	500
Spacelab payload development	(---)	(1,000)	(1,000)	2,200
Total	(12,080)*	(14,500)*	(14,500)*	15,200

* Program transferred from Space Science to Space Applications, January 1979; FY 1979 and prior funding not included in totals.

OBJECTIVES AND STATUS:

The upper atmospheric research program is primarily aimed at pursuing a comprehensive effort toward under-

standing the Earth's upper atmosphere. In particular, the goal is the improved prediction of man's impact upon the ozone layer and the effects of changes in the upper atmosphere upon our environment. In order to accomplish this, efforts are underway: (1) to improve upper atmospheric models, validate them and assess their uncertainties; (2) to measure minor chemical constituents, temperature, and radiation fields in the upper atmosphere using balloon, rocket, and aircraft experiment platforms as well as ground-based measurements; (3) to develop sensors capable of remotely sensing all aspects of the upper atmosphere from space; (4) to assemble and maintain the existing long-term data base of stratospheric ozone measurements made by all types of techniques, including satellites, for the purpose of uncovering long-time scale natural variations and detecting man-made ozone changes; and (5) to carry out laboratory kinetics and spectroscopy studies to support these other activities.

Significant new simultaneous measurements of numerous stratospheric species have been accomplished and several coordinated balloon flights have been completed. Approximately 130 tasks are supported, involving elements of the Government, university, and industrial research communities. Results from theoretical studies have emphasized the close coupling of the nitrogen, hydrogen and chlorine compounds. New laboratory results have provided improved data required for models and the interpretation from our field measurements program. New measurement techniques have been demonstrated. A reaction rate panel has been established. An extensive workshop is scheduled to assess the status of the ozone depletion problem and planning is underway for an Upper Atmospheric Research Satellites (UARS) program to provide a comprehensive investigation of the energetics, composition, and dynamics of the stratosphere and mesosphere.

The balloon support program provides for instrument development and testing, and provides for a large number of direct and remote atmospheric measurements in the altitude range up to about forty-five kilometers.

Initiation of activities for follow-on principal investigator class payloads beyond Spacelab-3 are underway. Definition studies for several multi-user facility instruments are being conducted.

BASIS OF FY 1980 ESTIMATE:

During FY 1980, a comprehensive program, directed toward understanding the upper atmosphere, will continue and intensify. In particular, the development of models which couple radiative, dynamic, and chemical processes will continue; the confirmation of chemical mechanisms by simultaneous measurements of stratospheric trace species will be extended; improvements in the laboratory kinetics and spectroscopy data base will be sought; and new and improved techniques will be developed for detecting additional trace species and remotely measuring winds. The research program will be extended into the mesosphere because knowledge of the coupling between these regions is necessary for understanding the complex interactions between radiation, chemistry, and dynamics in the upper atmosphere and the relationship between solor variations and terrestrial weather and climate. These studies will support the International Middle Atmosphere Program (MAP) in the mid-1980's.

The balloon program will be continued at about the current level of approximately 45 flights per year. Evaluation and selection of atmospheric experiments for follow-on Spacelab missions will be completed. Definition studies for a Spacelab LIDAR system and a cryogenically-cooled, limb-scanning interferometer radiometer (CLIR) will be continued.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

APPLICATIONS SYSTEMS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Airborne instrumentation research program	9,100	5,800	5,800	10,300	7-39
Data management	2,000	1,500	1,500	1,500	7-39
Applications data service definition	---	---	---	2,400	7-40
Shuttle/Spacelab mission design and integration	2,240	6,900	6,400	8,300	7-41
NASA integrated payload planning	(4,000)*	4,000	2,000	1,700	7-41
Total	13,340	18,200	15,700	24,200	
Space Transportation System Operations	(---)	(2,600)	(2,600)	(18,000)	

(*Funded under Space Flight Operations in FY 1978 and prior years.)

OBJECTIVES AND STATUS:

Applications Systems provides support in the areas of flight system support, data systems, and integrated payload planning. In the area of flight system support are included both research aircraft and payload integration for Shuttle/Spacelab missions. The data systems activity includes the overview of all data management activities on a program-wide basis, as well as definition activities associated with the Applications Data Service. The integrated payload planning function includes the analysis and formulation of all NASA Shuttle payload requirements for the Space Transportation System.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars		
Airborne Instrumentation Research Program (AIRP)....	9,100	5,800	5,800	10,300

OBJECTIVES AND STATUS:

The objective is to provide airborne research facilities for the definition and testing of remote sensing instruments; the development and demonstration of remote sensing interpretive techniques; the verification of data acquired by spacecraft sensors; and for the direct sensing measurements for stratospheric research programs. Capabilities provided include five research aircraft, airborne remote sensing instruments, and data processing equipment and services.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funds will be used to conduct airborne remote and direct sensing measurement flights in support of FY 1980 research requirements emanating from resource observations and environmental observations programs. Projected flight capability is designed to meet major objectives and program thrusts at a level of funding commensurate with accomplishing priority needs. The increase in the funding level from FY 1979 to FY 1980 reflects a change in the management approach to include flight peculiar costs within the project. In FY 1980, all airborne research operating costs will be funded through the Airborne Instrumentation Research Program.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Data Management.....	2,000	1,500	1,500	1,500

OBJECTIVES AND STATUS:

The objective of the data management effort is to define needs for extension of current technology to accommodate increased volume, complexity, and the concurrent high rates of data, and to reduce origin-to-user transmission times. Users must also be provided with improved capabilities for rapidly storing and retrieving the required data products. An understanding of the current and near-term future technology exists and longer range technology needs are being analyzed.

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BASIS OF FY 1980 ESTIMATE:

In FY 1980, modeling efforts will be completed on data/information products to demonstrate data compressibility and effort will be continued to assure that advanced data technology is developed. Study efforts will begin on cross-correlative multi-disciplinary data information overlay techniques, mosaicking and handling textural data for large data sets.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Applications Data Service Definition.....	---	---	---	2,400

OBJECTIVES AND STATUS

The objective of the Applications Data Service (ADS) definition activity is to analyze approaches for meeting economically and efficiently future applications data access and integration needs. In the 1980's, effective use of information gained from multiple sources is key to the users success in dealing with large scale modeling in agriculture, ocean studies, and weather and climate forecasting. This requires timely access to and integration of data from a dozen or more interdisciplinary sources.

The ADS will be planned to build upon existing and planned applications data systems, encourage the convergence of those systems and their products into a compatible and integrated structure through the definition of data and data systems standards, and to develop a network service for data transmission and integration.

ADS preliminary requirements, concept and feasibility studies presently are underway and will be completed by the end of FY 1979.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding will be used to define standards and to initiate contracts for ADS network service definition. Completion of standards definition by the end of FY 1980 will allow these data and data systems standards to be implemented in the major next generation systems being defined in the areas of resource observations and environmental observations. The definition activities are expected to take two years.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Shuttle/Spacelab Mission Design and Integration.....	2,240	6,900	6,400	8,300

OBJECTIVES AND STATUS:

The objectives of the Mission Design and Integration activity are to plan, design, and implement missions in response to experiment requirements. These activities include integrating instruments into attached payload carriers and conducting the associated flight and ground operations. Preparations are in progress in support of the applications experiments and instruments to be flown during the Space Shuttle orbital flight test missions. In addition, activities in support of the applications payloads planned for Spacelab-3 are proceeding. Efforts for follow-on missions are in various stages of planning and definition of experiment interfaces.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The current estimate for FY 1979 is based on rephasing of activities consistent with the delay in the near-term Space Transportation System missions.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 funds are required to support ground and flight mission management operations for the applications experiments to be conducted during the Shuttle orbital flight test missions. Included are the Shuttle imaging radar and multispectral infrared radiometer instruments and the measurement of air pollutants from satellites and the ocean color experiment. Progress will continue in support of the space processing and atmospheric cloud physics laboratory experiments to be carried out during the Spacelab-3 mission. In addition mission planning, design, and integration efforts for follow-on applications experiments will be underway. These efforts are phased to meet the mission activity level to support experiments currently under development.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
NASA Integrated Payload Planning.....	(4,000)	4,000	2,000	1,700

OBJECTIVES AND STATUS:

The objectives of integrated payload planning are to coordinate and consolidate NASA's plans for early Space Transportation System (STS) missions to ensure hardware and operational compatibility between the payloads and the STS elements. The FY 1979 effort continues tasks directed toward determining the most economical and effective means of utilizing the STS and assuring payload and STS compatibility. Studies are providing for completion or additional definition of key payload/STS interfaces, mission planning, and integration processes. Support is also being provided for the analysis of requirements for physical (Level IV) integration of payloads.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The reduction in planned payload and mission planning activities for FY 1979 is due to rescheduling of the first STS missions and the planned near-term Spacelab missions.

BASIS OF FY 1980 ESTIMATE:

During FY 1980, those tasks will be identified or continued which are essential to establishing the most economical and effective means of utilizing the STS and assuring hardware and operational compatibility between payloads and STS elements; these tasks will also clearly be multi-program or generic in nature and not within the cognizance of any one program area. Particular areas of concern will be clarifying specific aspects of STS accommodations for payloads and the impact of Level IV decisions on the integration flow interfaces between the STS and payloads. In addition, payload requirements for future STS augmentation or modification will be analyzed to ensure that the most economical and effective utilization of the STS is planned.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

TECHNOLOGY TRANSFER

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Applications systems verification and transfer.....	(1,200)	1,150	1,150	1,700
Regional remote sensing applications.....	2,700	2,500	3,500	3,800
User requirements and supporting activities.....	5,600	5,500	4,500	4,800
Civil systems.....	2,100	1,800	1,800	---
Total.....	10,400	10,950	10,950	10,300

OBJECTIVES AND STATUS:

The objectives of the remote sensing Technology Transfer program are to provide for the validation, transfer and widespread dissemination of proven technology applications to operational use.

The Applications Systems Verification and Transfer (ASVT) program conducts the demonstration, verification and transfer of total applications systems in a representative user setting and with participating user organizations, emphasizing cost reduction and system compatibility with the user setting. The program is increasing the awareness and use of remote sensing by other Federal agencies and by state governments. Projects are now underway with the Corps of Engineers, the Pacific Northwest and Appalachian Regional Commissions, the State of Texas, the National Oceanic and Atmospheric Administration, and the U.S. Geological Survey. Those projects are being supplemented with an additional project with the National Park Service in FY 1979.

Through the Regional Remote Sensing Applications Program, over 500 state agency personnel have undergone training and/or orientation programs since January 1977. Multi-disciplinary demonstration projects now involving seventeen states are being conducted, and are providing these states with a firm basis for evaluating the potential for operational use of remote sensing technology. In addition, follow-on assistance programs are helping an additional four states establish operational programs.

Under User Requirements and supporting activities, continuing communciations are maintained between NASA and the user community to determine user needs, inform users of existing and planned technological capabilities, obtain external evaluations of Space Applications programs for planning purposes, and develop pro-

gram awareness and technical capabilities in educational institutions. In the past year, we have established formal interfaces with national and representative organizations (National Conference of State Legislatures, National Governors Association) that have significantly focussed and accelerated state government interest in technology transfer through increased awareness and establishment of two-way communications. Newly established communications with the private sector are aimed at developing increased cooperation between NASA remote sensing programs and industry suppliers and stabilizing the sources of future assistance for operational users of remote sensing. We are continuing to encourage the development of geographically-distributed university capabilities to demonstrate the practical benefits of remote sensing through the conduct of research, education and public service activities. About twenty universities are currently participating in the program, with recent additions expanding the technical area of interest from remote sensing to include space processing.

Technology transfer engineering projects conducted within the Civil Systems program have been transferred to the Technoloty Utilization Program to consolidate all Terrestrial Applications engineering projects.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The total FY 1979 estimate for this program element has not changed. However, a reallocation of $1 million from User Requirements and supporting activities to the Regional Remote Sensing Applications Program in FY 1979 was accomplished to reflect more clearly the division between those activities that are national in scope (retained in User Requirements and supporting activities) and those programs that are intrinsically part of field center (Regional) programs.

BASIS OF FY 1980 ESTIMATE:

Major emphasis for FY 1980 will be in the following areas:

Demonstration projects (ASVT's) with the State of Texas (Natural Resources Inventory/Monitoring) and the Appalachian Regional Commission (lineament analysis/shale deposit detection) will be completed in FY 1980, as will the operational implementation of the DAM (water impoundment inventory) capability with the Corps of Engineers. In FY 1980, approximately four new ASVT's will be initiated. Program thrusts in FY 1980 will address more advanced geo-based information systems and private sector applications such as with architect/engineering consultants, geothermal exploration companies and agro-business. In addition, in FY 1980 private industry will be utilized more fully in conducting projects with users.

Under the Regional Remote Sensing Applications program the transfer of Landsat applications technology to state governments will be continued through established training, demonstration and technical assistance projects. Programs in an estimated eight to ten states will be completed in FY 1980. Follow-on projects

and full scale demonstrations (for which preliminary work will be completed in FY 1979) in approximately fifteen states, will be supplemented by the initiation of programs in four to five additional states. Liaison training and prototype demonstration projects will be initiated with representative substate user groups, such as counties and regional councils. As with the ASVT program, increased reliance will be placed on enhancing private sector/user interfaces through cooperative activities.

The User Requirements and supporting activities effort will continue the formal institutional relationship with the National Governors Association (NGA) and the National Conference of State Legislatures (NCSL) with emphasis on the development of a long term plan for NASA, state and local activities; provide for an increasing involvement of the private sector in NASA's transfer efforts as both a user and a producer/supplier; and emphasize user awareness and the requirements of the regional and local governments. Supporting program studies will include evaluation of the human and institutional factors in the transfer process and an evaluation of incentives to increase private industry involvement in remote sensing. In addition, it is planned to continue to phase in new universities (two to three in FY 1980) as other programs are completed. FY 1980 activities will address the likely need for expanding program coverage to new disciplines such as geology, weather-climate, atmospheric applications, etc. Selection of new universities and of tasks to be conducted will be made in concert with the Regional Remote Sensing Applications Program to reinforce the establishment of capabilities at state and local levels to use remote sensing data to meet operational needs.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

MATERIALS PROCESSING IN SPACE

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Space processing applications rocket (SPAR) project..	3,900	3,600	3,600	2,100	7-47
Applied research and data analysis.....	4,350	4,400	4,400	6,900	7-48
Shuttle/Spacelab payload development.....	5,400	12,400	12,400	10,800	7-49
Total.....	13,650	20,400	20,400	19,800	

OBJECTIVES AND STATUS:

Materials Processing in Space (MPS) emphasizes the fundamental science and technology of processing materials under conditions that allow detailed examination of the constraints imposed by gravitational forces. Its goal is to test and demonstrate the capabilities of the space environment for materials processing and provide opportunities for independently funded users to exploit space flight for processing activities related to their own needs. As these development, test, and demonstration efforts proceed, the technology will be transferred, as appropriate, to non-NASA users for their use.

Activities in FY 1980 are planned to implement the recommendations of the National Research Council's recent study of "Scientific and Technological Aspects of Materials Processing in Space" (STAMPS), which recommended increased emphasis on ground-based research in several basic areas: closer ties with the scientific community in generating new projects and reviewing progress; and a policy of transferring sponsorship of space activity in materials science and technology to private and non-NASA public organizations as soon as adequately demonstrated techniques become available. In response to the STAMPS recommendations, NASA plans to increase the level of its ground-based research effort, to carry on a continuing program of interface activities with commercial interests, and to confine new flight project initiatives to areas where needs have been documented by prior research.

During FY 1980, the Space Processing Applications Rocket (SPAR) project will conclude its sounding rocket flight operations with two launches and will complete development of the Materials Experiment Assembly (MEA), a system of interface hardware that will enable SPAR payload apparatus to be used in the Shutt' payload bay, thereby prolonging the useful life of the SPAR hardware. The MEA capability may be use complete some SPAR investigations that can benefit from the Shuttle's longer flight duration.

Fourteen principal investigators have been selected to date to perform materials experiments on the Space Transportation System. They are currently at work on their preparatory ground-based research, in concert with the contractor (TRW) selected in 1978 to develop major equipment items and perform integration tasks. Design of the first group of MPS payload equipment to be built specifically for STS missions will be completed by the end of FY 1980. Correspondingly, the principal investigators in the experiment program for which the equipment is being developed will finalize their plans for experiment implementation.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Space Processing Applications Rocket (SPAR) Project...	3,900	3,600	3,600	2,100

OBJECTIVES AND STATUS:

The objective of the SPAR project is to perform applications materials processing flight experiments and related ground-based research on applications of weightlessness to materials processing, in areas where the five minutes of weightlessness available in sounding rocket flights can be useful. The project comprises a group of 26 investigations in materials science and technology, competitively selected from among the responses to three Announcements of Opportunity in 1974-77. Each SPAR payload is configured to meet the requirements of a specific group of investigators whose experiments are ready to fly, and carries from three to five separate experiments. Most investigations in the project require more than one flight to accomplish their objectives.

SPAR rocket flight operations are planned to continue through 1980. The work already accomplished has operationally demonstrated several capable items of new equipment, including apparatus for rapid directional solidification and both electromagnetically and acoustically-suspended containerless processing. It has been found that some of the more sophisticated rocket payload equipment can be useful for experiments on the the Space Transportation System (STS); a set of interface hardware collectively known as the Materials Experiment Assembly (MEA) is being developed by the SPAR project to permit use of this type of apparatus on Shuttle missions. In general, use of the MEA on STS missions will be included in the Shuttle/Spacelab experiment program, although some of the SPAR investigations may be completed on STS flights.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, it is planned to fly two rocket flights with three to five experiments per flight, supported by appropriate preparatory research and post-flight analysis by the principal investigators. In addition, fabrication and checkout activities will be completed for the MEA, leading to its availability for flight by the end of the fiscal year.

Applied Research and Data Analysis (Materials Processing)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Ground-based investigations, analysis, and studies...	4,350	4,400	4,400	6,900

OBJECTIVES AND STATUS:

The Applied Research and Data Analysis (AR&DA) activity in the Material Processing in Space program is structured to emphasize ground-based research in subject areas from which space investigations with applications potential are expected to develop. In addition, the AR&DA program supports technology development for future ground and space capabilities, equipment definition studies responding to identified space experiment needs, and commercialization activities looking toward space activity by private industry.

Current activities are concentrating on science and technology work on infrared detector materials, inertial confinement fusion targets, floating zone crystal growth, separation and synthesis of biological materials, containerless processing, heat pipe technology and space vacuum utilization. The commercialization effort includes studies of institutional, legal and economic issues; information activities directed toward industry; and discussions with companies which express interest in undertaking joint space endeavors with NASA. Since FY 1978, most of the activities have been initiated in response to proposals from the scientific community, and this approach will be continued in FY 1980.

BASIS OF FY 1980 ESTIMATES:

In accordance with recommendations made in the National Research Council's study of "Scientific and Technological Applications of Materials Processing in Space," an increased level of effort is planned in ground-based research and development to provide a basis for thoroughly prepared, scientifically justified space flight investigations in the future. With augmented AR&DA funds, MPS will be able to accept an increased number of meritorious research proposals from the scientific community while maintaining continuity in the emphasis areas initiated in FY 1978 and 1979. In addition, critical technology development work will be performed in support of more mature investigation areas, to ensure that the required payload capabilities can be provided when flight experiments are undertaken in these areas.

Shuttle/Spacelab Payload Development (Materials Processing)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Payload development	5,400	12,400	12,400	10,800

OBJECTIVES AND STATUS:

The Space Processing Shuttle Payloads project includes the design and development of a basic set of payload equipment for space experiments on materials and processes, and provisions for conducting an initial set of experiments with this equipment on Space Transportation System (STS) flights through 1982. Fourteen investigations have been selected for the initial experiment program, covering topics in crystal growth, fluid flow effects, physical metallurgy, specialized composite materials, and advanced glass technology. All of the equipment will be designed for repeated use and a long service lifetime, so that other experimenters can make use of it in later years.

All of the principal investigators selected for flight are now under contract and performing their preparatory ground-based research; in addition, an investigators' working group has been formed and is overseeing the equipment design and the definition of mission requirements. TRW has been engaged as the prime contractor to build two major payload facilities, the Fluid Experiments System (FES) and the Solidification Experiments System (SES), as well as to integrate the entire payload. A third multiuser facility, the Acoustic Containerless Processing Module (ACPM) is being designed by the Jet Propulsion Laboratory. Three of the investigators will use equipments peculiar to their experiments which are being developed under separate contracts.

BASIS OF FY 1980 ESTIMATE:

Design work will be completed on all payload apparatus in FY 1980, leading to critical design reviews and initiation of manufacturing in April for the FES and in July for the SES and the ACPM. At that time, the principal investigators will freeze their experiment implementation requirements for the first flights of the apparatus and begin work on preparation of flight samples and refinement of process parameters. A Ground Control Experiments Laboratory containing apparatus identical to the flight equipment in all scientifically significant respects will be set up in August-November for ground-based simulation and comparison experiments by the investigators. This activity will proceed at a level of effort leading to delivery of flight articles in 1981 and first flights of the apparatus in 1982.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

SPACE COMMUNICATIONS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Search and rescue mission	5,600	8,000	8,000	5,000	7-51
Shuttle/Spacelab payload development	1,000	1,200	1,200	1,400	7-52
Technical consultation and support studies	3,100	3,100	3,100	3,000	7-53
Applied research and data analysis	5,650	3,700	3,900	6,200	7-54
Follow-on data analysis and operations	3,800	4,500	4,500	3,800	7-56
Total	19,150	20,500	20,700	19,400	

OBJECTIVES AND STATUS:

The objective is to provide for efficient and effective use of limited geosynchronous orbit and radio spectrum resources while promoting United States leadership by support of technology development in satellite communications. The communications research and development effort reflects the recent Presidential space policy stating that United States leadership in communications satellite systems will be supported by NASA and that selected technological opportunities to provide better frequency and orbit utilization and other longer-term opportunities will be pursued. The effort, incorporating the advice of the communications industry, will complement private sector research and development. In FY 1980, the communications program will focus on the development of a strong technology base--particularly in the development of multibeam antennas and on-board switching techniques--from which future plans for developing new capabilities and flight test programs can grow.

FY 1980 funds will support the continued development of the Adaptive Multibeam Phased Array (AMPA) antenna. This antenna will, on command, conduct experiments in forming, shaping, and pointing its transmit and receive beams quickly to ground users in different locations, while avoiding interference.

The experimental Search and Rescue satellite program, which will use satellites to aid in the detection and location of distress beacons carried by ships and aircraft, will continue in FY 1980. During FY 1979, we will modify the appropriate NOAA operational meteorological spacecraft (NOAA-E, -F, -G) to accept Canadian and French equipment, develop spacecraft antennas, build a ground station to accept satellite data and develop a flight test program. This work is done in conjunction with the Departments of Transportation and Defense and with France and Canada.

FY 1980 funds will support the continued operations of ATS-1 and ATS-3, while providing for the orderly phaseout of the ATS-6 and CTS public service user experiments and demonstration. These funds will also provide for the transition of Federal Public Service Communications activity from NASA to the National Telecommunications and Information Administration within the Department of Commerce. During FY 1980, we will work with the National Telecommunications and Information Administration and its Interagency Committee on Satellite Telecommunications Applications (ICSTA), representing 18 Federal agencies, to undertake technology development which will meet the needs of a growing national satellite communications community.

Search and Rescue Mission

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Search and rescue mission	5,600	8,000	8,000	5,000
Atlas (expendable launch vehicles program)	(---)	(---)	(---)	(2,000)

OBJECTIVES AND STATUS:

The objective of the Search and Rescue Mission is to demonstrate the feasibility of using satellites to provide a significant improvement in the capability for search and rescue forces to detect and locate distress signals from general aviation aircraft and certain marine vessels during emergencies. Systems studies have shown that satellites flying at an 850 kilometer altitude can detect the emergency beacons presently carried by aircraft and ships. Preliminary calculations indicate that the satellite can fix the position of these beacons to an accuracy of about 15-20 kilometers, and could position a proposed new beacon, with its stronger signal, to about 5 kilometers. This will permit rescue forces to arrive at the accident scene more quickly than is presently possible.

This interagency program is being conducted jointly with Canada and France; discussions with the Soviet Union are also underway. The U.S. will provide the spacecraft, launch vehicle, and the U.S. ground stations; the Canadians will provide the space telecommunications equipment and ground station in their country; and France

will provide an onboard processor and receiver. In addition to NASA, the Departments of Defense, Transportation, and Commerce (NOAA) are expected to participate in the program test and evaluation phase.

Presently, we are designing the modifications which will enable the NOAA-E spacecraft to accept search and rescue instruments; the specifications for a new improved 406 MHz Emergency Locator Transmitter are being prepared; and required additions to existing NOAA ground stations are underway.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding will support the modification of the NOAA-E, -F, and -G spacecraft, enabling them to accept a Canadian-provided transponder and a French-provided on-board processor. FY 1980 efforts will also focus on developing "receive and transmit" spacecraft antennas and continuing the development of the advanced emergency beacon to conduct search and rescue experiments.

Shuttle/Spacelab Payload Development (Space Communications)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Payload development	1,000	1,200	1,200	1,400

OBJECTIVES AND STATUS:

The objective is to develop promising communications payloads that will capitalize on the unique capabilities of the Space Shuttle and Spacelab missions beginning in the early 1980's.

In FY 1979, development work will continue on an Adaptive Multibeam Phased Array (AMPA) antenna that will provide a significant improvement in the radiated power that can be received by ground-based communications systems. This type of spaceborne antenna has direct applications to education, health care delivery and postal services, and for service to small mobile terminals that might be used on trucks and autos, and data collection platforms.

Airborne Instruments Laboratory, on contract with the Goddard Space Flight Center, has begun the design of the AMPA antenna that, on command, can form, shape, and point its transmit and receive beams quickly to small ground areas in different geographic locations, while avoiding interference. AMPA will be ready for flight in 1982.

BASIS OF FY 1980 BUDGET ESTIMATE:

FY 1980 funding will support the continued development of the 32-element phased array antenna to operate at 1.6 GHz. FY 1980 activities will include development, manufacture, assembly and test of the instrument at the system level, in preparation for an early Spacelab mission. This will include the development of needed ground equipment and experimental platform units.

Technical Consultation and Support Studies

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Technical Consultation and Support Studies.....	3,100	3,100	3,100	3,000

OBJECTIVES AND STATUS:

The objective of this program is to provide technical consultation, special studies, and experiments on frequency and orbit utilization for NASA and other U.S. Government agencies. Studies and experiments being performed help provide technical and regulatory frameworks to allow growth of existing satellite services and provide for the inclusion of new satellite applications. The effort is grouped into three main categories: orbit and spectrum utilization; satellite systems support; and communciations satellite application system studies.

Orbit and spectrum utilization includes the development of frequency and orbit sharing techniques and strategies, design standards, and the determination of the effects of propagation phenomena and man-made noise on performance, design, and orbit and spectrum utilization of space telecommunication systems.

Satellite systems support includes design and flight readiness reviews and technical assessments on Intelsat and Domsat systems for the Federal Communications Commission (FCC) and special studies on high priority FCC and NASA program office requests.

Communications satellite application system studies are structured to meet, primarily, statutory and regulatory requirements and to ensure compatibility of NASA flight programs with other space and terrestrial services.

These studies and experiments supported U.S. preparation and NASA participation in the October 1978 Special Preparatory Meeting leading to the 1979 World Administrative Radio Conference.

BASIS FOR FY 1980 ESTIMATE:

In FY 1980, emphasis will be placed upon the completion of our preparation and participation in the 1979 World Administrative Radio Conference (GWARC) and an assessment of its results and implications for U.S. telecommunciations. Studies will be expanded in support of the 1983 Region 2 (Western Hemisphere) Conference on Broadcast Satellites.

FY 1980 studies and experiments will be undertaken in the areas of active and passive microwave sensors essential to resource and environmental observations; broadcast and mobile satellite services; emergency and disaster communications; energy transmission from space; and techniques, models, and strategies for improving the use of the radio frequency spectrum and the geostationary orbit.

Applied Research and Data Analysis (Space Communications)

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Advanced communications research	4,300	2,300	2,300	4,200
Wideband 30/20 GHz definition	---	---	---	1,200
Applications pilot test	1,100	1,100	1,300	800
Development of advanced flight experiments	250	300	300	---
Total	5,650	3,700	3,900	6,200

OBJECTIVES AND STATUS:

The Applied Research and Data Analysis (AR&DA) activities consist of system studies, development of technology for proof-of-concept flight programs, and experiments which provide new technology and technique concepts to aid private industry in offering new, improved and affordable communcations services. Specifically, NASA will concentrate on the development of multi-beam space antennas and on-board switching techniques, as well as associated system technologies.

Technology development is directed toward the efficient and effective use of the limited spectrum and orbit resources. This objective has been supported through the development of bandwidth compression techniques and new "frequency re-use" space antenna methods. Data collection technology has also been developed which lowers the cost and improves the efficiency of data collection platforms.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The Applications Pilot Test Program budget was increased to facilitate increased personnel training capability at the Denver Uplink Terminal in order to effectively complete technology transfer efforts prior to the end of public service user experiments on ATS-6.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funding will support two essential technology efforts in Advanced Communications Research to be undertaken in conjunction with the Office of Aeronautics and Space Technology (OAST): systems development and component development. The Office of Space and Terrestrial Applications (OSTA) will address the complex systems aspects of commercial satellite communications in several ways, including development of concepts for major subsequent decisions regarding traffic type, size, costs, and schedules. The associated systems hardware development concentrates on the performance of multi-beam antennas and on-board switching. The OAST will undertake the development of specific, identified, hardware components to include multi-beam antenna switches, efficient power amplifiers, and low-noise mixers. Some propagation modeling and ground terminal technology development at 30/20 GHz will also be undertaken.

In addition, funds are requested for a "Wideband" project definition activity to provide systems analysis and project definition which will enable the use of the 30/20 GHz band, allowing a proof-of-concept test for demonstrations of capacity and understanding of propagation effects.

In the Applications Pilot Test program, NASA will continue to support the public service communications project with the Public Service Satellite Consortium for the conduct of satellite communications experiments. In addition, at the request of the U.S. Coast Guard, we are conducting a demonstration to aid in locating vessels in the 200-nm Coastal Zone; in this demonstration, participating ships will relay their LORAN-C derived navigation data through an existing geostationary satellite to a ground-based computation center.

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Follow-on Data Analysis and Operations

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Follow-on Data Analysis and Operations.....	3,800	4,500	4,500	3,800

OBJECTIVES AND STATUS:

The objective is to provide for a wide range of user experiments and demonstrations in the application of satellite communications. Experiments with the ATS-6 and CTS spacecraft have generated a great deal of interest, both nationally and internationally, in satellite telecommunciations. Nearly 400 communications experiments using ATS-6 and CTS have been successfully conducted during the extended lifetimes of these satellites to provide user experience for making decisions regarding their communications functions. NASA's stimulus in encouraging use of these unique facilities is now leading to use of commercial satellites which can better meet the needs for flexibility and continuity of services. NASA is supporting this transition. Complete reports on experiment results will be prepared for use by many interested groups that did not directly participate.

BASIS FOR FY 1980 BUDGET ESTIMATE:

FY 1980 funding will provide for continued support of the ATS-1 and -3 experimentation and support ties. Public service user experiments on CTS will be completed by June 30, 1979, and experiments on A. by September 30, 1979. FY 1980 will begin the phasedown years, during which results of 400 experiments performed since 1969 will be appropriately compiled so that the results may be of value to future activities following the ATS-6 and CTS experiments. These final reports will also support the National Telecommunications and Information Administration's efforts to transfer the public service satellite communications community to commercial satellites and services. A continuing activity in this support will be the Systems Architecture Study in which a thorough and careful investigation of all practical commercial communications links for the Public Service user is made.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS

TECHNOLOGY UTILIZATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
Technology dissemination	3,600	3,715	3,600	3,800	8-3
Technology applications	4,100	4,110	4,100	4,400	8-4
Program evaluation and support	1,400	1,275	1,400	1,500	8-4
Civil systems*	(2,100)	(1,800)	(1,800)	2,400	8-4
Total	9,100	9,100	9,100	12,100	
Distribution of Program Amount by Installation:					
Johnson Space Center	100	250	160	200	
Kennedy Space Center	195	100	90	150	
Marshall Space Flight Center	635	600	482	500	
National Space Technology Laboratories	—	100	—	50	
Goddard Space Flight Center	680	550	857	900	
Jet Propulsion Laboratory	539	500	477	1,700	
Wallops Flight Center	10	100	4	200	
Ames Research Center	857	800	595	1,000	
Dryden Flight Research Center	67	100	54	60	
Langley Research Center	868	750	938	1,000	
Lewis Research Center	256	200	328	400	
Headquarters	4,893	5,050	5,115	5,940	
Total	9,100	9,100	9,100	12,100	

*Beginning with FY 1980, this effort is to be funded in Technology Utilization instead of Space Applications.

OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS — TECHNOLOGY UTILIZATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION

Technology Utilization Program objectives encompass the transfer of new knowledge and innovative technology resulting from NASA aeronautical and space R&D programs for application and use in industry, medicine and important public sector areas such as transportation, environment, urban development and public safety. Specific program objectives are:

(1) To expedite and facilitate the application and use of new technology, shortening the time between generation of advanced technologies and their use in the economy;

(2) To encourage multiple secondary uses of NASA technology in industry, education and government where there is a wide spectrum of technological problems and needs;

(3) To understand more fully the technology transfer process and its impact on the economy, and to manage and optimize the process in a systematic way; and

(4) To develop applications of NASA's aerospace expertise - its technology, technologists and unique facilities - to priority non-space needs of the nation.

Aerospace technology is transferred to the public and private sectors of the nation's economy through a variety of established mechanisms developed and managed under the NASA Technology Utilization Program. These mechanisms or project areas include: publications and announcements, Industrial Applications Centers, the Computer Software Management and Information Center (COSMIC), State Technology Applications Centers, applications teams/applications engineering projects, and civil systems projects.

OBJECTIVES AND STATUS:

During the past year, NASA's Tech Brief journal for announcing available technology continued to generate more interest and awareness in the industrial community than at any time previously. The rapid growth and expansion of the Tech Brief mailing list (over 1,300 new addresses per month) and over 60,000 journal-related industrial inquiries received by NASA during 1978, are positive reflections of this sustained interest.

NASA Industrial Applications Centers (IACs) and the Computer Software Management and Information Center continued to increase in number of industrial clients and income during the past year. IAC industrial income for 1978 was $2.2 million compared to $1.8 million for the previous year. COSMIC income was up by 40% when compared with 1977. In addition, a cooperative project with the Small Business Administration to provide IAC services to over 700 small businesses in southern California and in the northeast has been highly successful, and similar efforts patterned after these experiments are planned in other regions of the U.S. in FY 1979 and FY 1980.

Over 70 applications engineering projects for adapting existing aerospace technology to defined needs in the public sector were active last year. These projects are jointly funded by NASA and user agencies such as DOT, HEW, EPA, and the Department of Commerce. Among the many projects are the portable firefighting module developed for the U.S. Coast Guard, a highly reliable water quality monitor for EPA, and a human tissue stimulator being developed in conjunction with Johns Hopkins University Medical Center (Pain Center) and the National Institutes of Health. Increasing attention will be devoted to the problems of the handicapped, with special emphasis placed on assisting the aged and developing aids for rehabilitation.

Transfer of the Civil Systems Program to Technology Utilization consolidates all NASA Terrestrial Applications engineering projects for public and private sector organizations. Current projects include the Advanced Ocean Technology Development Platform (AOTDP) for use in evaluating and generating new deep ocean instrumentation and sensors; environmental sensors and systems to detect and analyze air and water pollutants; applications of aerial thermography for energy conservation; and assistance to the U.S. Coast Guard and NOAA in implementing project ICEWARN, which utilizes side-looking airborne radar technology to monitor ice formations on the Great Lakes shipping channels.

Documented evidence of technology transfer (i.e., the annual "Spinoff" report) is continually recorded, evaluated and disseminated to industry and the general public as a means of creating widespread awareness of program activities and available NASA technology transfer services. Efforts continue on methods and procedures to increase the efficiency and effectiveness of all programs.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The FY 1979 adjustment between technology dissemination and program evaluation and support results from increased changes for data bank computer support for information retrieval activities at NASA's Scientific and Technical Information Facility.

BASIS OF FY 1980 ESTIMATE:

Technology Dissemination

In FY 1980, NASA plans to improve service to users of TU publications (e.g., NASA Tech Briefs) by providing field center support for inquiry handling and technical support package preparation; permitting NASA Industrial Applications Centers and COSMIC to develop new user marketing strategies; expanding market penetration of

selected industrial segments (e.g., small manufacturing firms); and providing additional geographical coverage of established IACs with remote sales personnel located in highly industrialized urban areas. IAC coordinator activities at NASA field centers will be continued to facilitate access to on-going NASA research and development programs for industrial users. The two State Technology Applications Centers (STACs) in Florida and Kentucky will broaden their experimental methods for transferring aerospace technology to state and local governments.

Technology Applications

In FY 1980, NASA's existing applications teams will place additional emphasis on transportation and public safety activities to focus on priority problems encountered in state and local government (e.g., Dade County Mass Transit System development project, fire safety, and law enforcement). Efforts will also be continued to respond to public sector application project opportunities in agriculture, mine safety, transportation, urban construction, medical diagnostic systems, and rehabilitation for the handicapped.

Program Evaluation and Support

In FY 1980, NASA plans to continue transfer research and impact studies to evaluate and quantify benefits resulting from TU program transfer mechanisms (e.g., cost-benefit evaluation of application teams). Economic analysis studies of NASA benefits resulting from direct as well as indirect secondary uses of NASA research and development will continue.

Civil Systems

In FY 1980, NASA plans to focus its institutional expertise on specific non-space problems in the areas of environmental monitoring and control, agricultural productivity, and deep ocean survey and exploration. In addition, the program will allow for a certain degree of flexibility in the selection of new projects that explore innovative applications of aerospace-derived technology to other non-aerospace-oriented disciplines. Specific projects include the extension of our atuomated water monitoring system to measure contaminants in potable water and monitoring the quality of natural water bodies. Completion of the field testing of the Agro-Environmental Monitoring System is expected in FY 1980 and demonstration of the applicability of advanced radar tracking techniques to insect monitoring will be accomplished. In the area of ocean technology, a definition study will be accomplished for a sea bed lander as part of the Office of Naval Research/Woods Hole Oceanographic Institute High Energy Benthic Boundary Layer Experiment (HEBBLE). This project will investigate a broad range of physical phenomena accompanying high velocity currents at the sea floor/ocean interface at depths of 3000 to 6000 meters.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES

RESEARCH AND DEVELOPMENT PLAN FOR AERONAUTICS AND SPACE TECHNOLOGY

Programs	1978 Actual	Budget Plan 1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Aeronautical research and technology	228,000	264,100	264,100	300,300
Space research and technology	97,700	108,300	107,300	116,400
Energy technology	7,500	3,000	5,000	3,000
Total	333,200	375,400	376,400	419,700

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY — AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
	(Thousands of Dollars)				
Research and technology base	97,805	109,200	109,200	117,500	9-4
System studies	3,000	3,000	3,000	3,200	9-18
Systems technology programs	75,765	85,645	85,645	106,100	9-20
Experimental programs	51,430	66,255	66,255	73,500	9-32
Total	228,000	264,100	264,100	300,300	
Distribution of Program Amount by Installation:					
Johnson Space Center	700	1,100	1,245	700	
Marshall Space Flight Center	756	1,100	958	900	
Jet Propulsion Laboratory	1,275	1,200	1,310	1,100	
Wallops Flight Center	953	500	619	700	
Ames Research Center	41,100	49,600	49,312	51,900	
Dryden Flight Research Center	14,423	9,100	9,047	13,400	
Langley Research Center	94,862	93,500	93,961	115,300	
Lewis Research Center	71,050	104,900	104,452	113,000	
Headquarters	2,881	3,100	3,196	3,300	
Total	228,000	264,100	264,100	300,300	

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY — AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Aeronautics program are to advance aeronautical technology to ensure safer, more economical, efficient and environmentally acceptable air transportation systems which are responsive to current and projected national needs; to maintain the strong competitive position of the United States in the international aviation marketplace; and to support the military in maintaining the superiority of the Nation's military aircraft.

The FY 1980 program supports these objectives by stressing the technology areas judged to be the most critical by in-house and external assessments, industry, advisory groups, and other users of technology within and outside the Federal Government. Emphasis will be placed on improving aircraft energy efficiency and performance; reducing noise and pollution; and improving safety and terminal area operations; and advancing long-haul and short-haul air transportation concepts.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

Funding adjustments between elements within the Aeronautical Research and Technology program have been made in response to changing program requirements which have developed since the budget estimates. Explanations of these funding changes are provided under each individual program involved.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 activities are designed to maintain a strong Research and Technology Base position in the technology disciplines of aerodynamics, propulsion, avionics and flight controls, human-vehicle interaction, materials and structures. The strength of this generic research and technology base is essential to enhance the growth of new, improved aeronautical products. The program also provides focused technology development activities for each of the major classes of aeronautical vehicles, i.e., conventional takeoff and landing (CTOL) aircraft, rotorcraft, general aviation aircraft, vertical/short takeoff and landing (V/STOL) aircraft, supersonic cruise aircraft, and high performance aircraft.

In the area of CTOL technology, progress in the aircraft energy efficiency efforts will continue toward the goal of providing, in the 1980's, the technology advances leading to a major reduction in aircraft fuel requirements. The design, fabrication and testing of individual components to validate the technology for use in next-generation, high-bypass turbofan engines will continue in the Energy Efficient Engine program. In the Engine Component Improvement program, the development of components with improved performance retention characteristics will be completed. In the Energy Efficient Transport program, work will continue with the major airframe contractors to develop and evaluate advanced aerodynamic and active control technologies for derivative and new subsonic transport aircraft. Included are wind tunnel tests of advanced winglet concepts. In the Laminar Flow Control (LFC) program, wind tunnel models will be evaluated, and the design of a full-scale LFC wing will be initiated. The safety effort will be continued with emphasis on human-vehicle interrelationships. The Fire Resistant Materials Engineering (FIREMEN) activity will be completed, providing technology for materials with improved fire resistance and low toxicity properties.

Rotorcraft technology activities will continue to address rotor aerodynamics, structures, avionics, flight dynamics, terminal operations, engines and drive systems, and rotor system design. Checkout flight tests of the new Rotor Systems Research Aircraft (RSRA) vehicles will be completed, and modifications will begin on existing helicopter rotors for flight test on the RSRA. An advancing blade concept (ABC) helicopter will be tested in the Ames Research Center's 40 by 80-foot wind tunnel to correlate wind tunnel data with flight test data.

In the area of general aviation, the development of technology for increased aerodynamic efficiency, crashworthiness, and reduced noise and emissions will continue, and the activity to develop the technology for advanced avionics systems with reduced complexity will be completed.

Vertical takeoff and landing technology efforts will emphasize broad-based technology for future military and civil aircraft applications. Short takeoff and landing (STOL) technology efforts will include ground-based simulator and flight investigations to develop design criteria applicable to quiet short-haul transports. The Quiet Short-Haul Research Aircraft (QSRA) will begin the flight experiments program to determine aero/acoustic characteristics, handling qualities, operating efficiency and certification criteria.

In supersonic cruise research, emphasis will be placed on the interactions between the airframe and propulsion system, long-life structural tests, wind tunnel evaluations, and the demonstration of advanced propulsion components for fuel-efficient variable-cycle engines with low noise and emissions.

In the area of high performance aircraft, efforts will continue on configuration aerodynamics, aeromechanical instability characteristics of advanced turbojet and turbofan engines, and two-dimensional exhaust nozzles. Flight testing of Highly Maneuverable Aircraft Technology (HiMAT) concepts will be continued, employing subscale remotely piloted vehicles.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

RESEARCH AND TECHNOLOGY BASE

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
Materials research and technology	6,300	7,300	7,300	7,500	9-4
Structures research and technology	8,740	11,500	10,600	11,700	9-5
Propulsion environmental impact minimization research and technology	9,725	10,300	10,300	10,500	9-7
Propulsion components research and technology	11,475	12,500	12,500	13,000	9-8
Air-breathing engine systems research and technology	8,670	8,800	8,800	8,900	9-9
Avionics and flight control research and technology	3,985	5,200	5,200	6,200	9-11
Aircraft operations and safety research and technology	4,810	5,500	5,500	6,600	9-12
Fluid and flight dynamics research and technology	14,495	16,500	16,500	20,700	9-13
Low-speed vehicle aerodynamics and flight dynamics research and technology	12,700	13,000	13,000	12,600	9-15
High-speed vehicle aerodynamics and flight dynamics research and technology	11,905	13,000	13,900	14,100	9-16
Human-vehicle research and technology	5,000	5,600	5,600	5,700	9-17
Total	97,805	109,200	109,200	117,500	
Materials Research and Technology	6,300	7,300	7,300	7,500	

OBJECTIVES AND STATUS:

The objective of the Materials Research and Technology program is to develop advanced metal, ceramic, polymer and composite materials needed to improve the performance, safety, longevity and economy of U.S. aircraft. Areas of emphasis include high temperature engine materials, life prediction procedures, and lightweight structural materials having high specific strength and stiffness.

Improvements have been made in the properties of several high temperature metal alloys, ceramics and composites that promise increased performance and efficiency in gas turbines and aircraft structures. Advances also have been made in the capability to predict the life of composites and metals which will improve the reliability of aerospace systems.

BASIS OF FY 1980 ESTIMATE:

Research on high temperature materials will continue to emphasize improving the strength and service life of gas turbine materials. During FY 1980, materials processing and design technology will be developed for an oxide dispersion alloy and a tungsten fiber reinforced superalloy which may have potential for hollow turbine blade applications. A manufacturing method will be developed to produce a low cost disk alloy having improved mechanical properties. Basic research on the mechanisms of corrosion and oxidation of turbine alloys will continue. Ceramic materials will continue to be developed, with emphasis on improving high temperature strength and impact resistance.

Research will continue on the fatigue fracture and behavior of metallic and composite materials in both benign and aggressive environments. Similar research will begin on ceramic materials. Research will be accelerated to extend existing life prediction techniques and analyses with emphasis on applying the method of strainrange partitioning to predicting the life of engine components. Studies will continue on the mechanism of hydrogen embrittlement of steels with the objective of developing hydrogen-resistant alloys. To predict service durability of composites, a damage growth law will be developed.

Research on composites will continue to be emphasized in the development of stiff, lightweight, strong structural materials. In FY 1980, research will continue to synthesize monomer reactants for use in polyimides, a high temperature class of resins. These resins will also be studied for use in low cost fabrication processes. At the Langley Research Center, a series of resins will continue to be improved and will be studied for possible application as adhesives. The fabrication and evaluation of boron/aluminum composites for high speed engine blades will continue in FY 1980. Research on large CTOL engine blades will be redirected toward improving impact resistant boron/aluminum technology. A data base will continue to be developed for the combustion characteristics and the thermochemical, thermalphysical and photochemical properties of new and advanced state of the art polymers.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Structures Research and Technology.....	8,740	11,500	10,600	11,700

OBJECTIVES AND STATUS:

The objective of the Structures Research and Technology program is to provide advanced technology that will result in significant improvements in the performance, safety, durability, and economy of commercial, military, and general aviation aircraft and helicopters. Major emphasis is given to advanced structural concepts for airframes, improved techniques for predicting structural loads and dynamic response, more accurate and efficient design methods for airframes and engines, and concepts for high speed airframe and engine structures.

Composite helicopter components have been developed for flight service evaluation, which will begin in late FY 1979. The performance of an active wing flutter suppression system has been verified in wind tunnel tests in preparation for drone flight testing in FY 1979, and the effectiveness of a wing/store flutter suppression system has been verified in wind tunnel tests. Energy-absorbing seat and restraint systems for light aircraft have been developed and evaluated in simulated crash conditions.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease of $900 thousand reflects a realignment of funds within the Research and Technology Base to provide increased wind tunnel support of high priority research in the high speed vehicle aerodynamics and flight dynamics area.

BASIS OF FY 1980 ESTIMATE:

FY 1980 funds provide for continued progress in investigating applications of composites in fixed-wing aircraft and rotorcraft. Emphasis will be placed on fuselage primary structures and the development of methods for evaluating and increasing the durability and damage tolerance of composite secondary components on commercial and military aircraft.

As a result of the in-house assessment, an increased emphasis will focus on the areas of structural dynamics and aeroeleasticity. The emphasis in FY 1980 will be on verifying the capability of active flutter suppression systems to increase flutter boundry speeds by 20 percent, developing methods for accurately predicting acoustic loads and noise transmission through structures and improving analytical and test methods for predicting unsteady transonic aerodynamic loads for wings and control surfaces.

Development of advanced design methods in FY 1980 will concentrate on analysis capability for predicting aircraft response to crash impacts, multidisciplinary methods for design of control configured aircraft, exploitation of advances in computer-aided design hardware, and improved understanding of structural failure mechanisms. Efforts will continue to improve crash safety of general aviation aircraft and emphasis on crashworthiness of commercial transport aircraft will be increased.

The efforts on turbine engine structures will be increased in FY 1980. Emphasis will be given to defining and developing the most promising applications of composites in advanced engines and to developing improved design and analysis methods needed to provide the technology for more reliable, lightweight engine structures, including hot section components. This effort will include such activities as an analysis to predict engine rotor transient dynamic response during loss of a fan blade.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Propulsion Environmental Impact Minimization Research and Technology	9,725	10,300	10,300	10,500

OBJECTIVES AND STATUS:

The objective of the Propulsion Environmental Impact Minimization Research and Technology program is to reduce noise and exhaust pollution from aircraft propulsion systems to environmentally acceptable levels in ways that are economically and operationally sound. The technology advances achieved will aid the aviation industry in developing new designs and will provide technical information to the Government for use in establishing noise and exhaust emission regulations.

In the area of forward velocity effects on propulsion system noise, the rotating fan blades of a Pratt & Whitney JT15-D engine have been modified and instrumented in preparation for a series of tests to correlate static and flight test noise data. The results of tests in the clean combustor program indicate that emission levels that compare favorably with proposed FY 1979 Environmental Protection Agency standards were obtained.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, research will be conducted to determine more accurately the phenomena of large scale exhaust motion in the generation of noise in jets, turbulence ingestion on rotating machinery noise and propeller noises. The understanding of these phenomena will support development of advanced noise suppression techniques. Investigations will be performed to determine atmospheric absorption characteristics of propulsion noise. Advanced analytical techniques will be developed for updating the aircraft noise prediction computer program. Experimental data will be gathered to validate the predictive capabilities of the program. In FY 1980, continued emphasis will be given to determining the effects of aircraft forward speed on propulsion generated noise. The OV-1 airplane is being modified to accommodate the JT15-D engine in order to conduct flight tests for noise measurements. These tests will provide the understanding needed to extrapolate the static data of advanced concepts to flight conditions.

Pollution reduction research will address the problems of aircraft piston engine emissions, as well as aircraft gas turbine emissions. The work is conducted at a fundamental level, seeking answers to the mechanism of pollutant formation and its control. In the gas turbine area, FY 1980 activities will continue on development of analytical pollutant formation models, and on advancing fundamental technology of combustion to support design of very low emission combustors for future generations of aircraft gas turbines. Aircraft piston engine emissions reduction technology efforts in FY 1980 will develop analytical methods of predicting emissions and will identify promising piston engine concepts, based on capability to operate with low emissions and acceptable fuel efficiencies.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Propulsion Components Research and Technology.....	11,475	12,500	12,500	13,000

OBJECTIVES AND STATUS:

The objectives of the Propulsion Components Research and Technology program are to increase air-breathing aircraft engine efficiency; to improve engine operations over a wide range of engine flow conditions; to reduce fuel consumption and weight, and to improve the reliability and durability of engine components. The efforts include research on gas path components, as well as mechanical components, fuels and propellers. This activity provides the advanced technology that ultimately supports improved, more cost effective and energy efficient propulsion systems for all applications--ranging from small, general aviation private aircraft to commercial transports and helicopters, as well as military aircraft of all types.

In FY 1979, the Propulsion Components Research and Technology effort continues emphasis on computational techniques. Added effort is also being given to solving problems unique to small turbine engine components.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, research on inlets and nozzles will continue to concentrate on development of analytical techniques which will accurately predict localized internal flow phenomena, including shock-wave/boundary layer interactions in the presence of boundary layer bleed. Detailed small scale experimental investigations will verify these fundamental internal flow processes.

Fan, compressor and turbine research in FY 1980 will reflect the increasing emphasis on utilization of computational techniques as a design tool. In addition, more effort will be devoted to identification and solution of those problems peculiar to small compressors of a size suitable for helicopter or small aircraft propulsion and small turbines, with particular attention to the design of effectively cooled turbines.

Next-generation commercial turbofan engines will operate at cycle pressures and temperatures significantly higher than current models. Combustor research in FY 1980 will continue to concentrate on solving the problems of durability, efficiency, and emissions which are related to the more severe operating cycles of advanced engine designs. Work on problems peculiar to small turbine engine combustors will be accelerated.

Fuels research is based on the premise that future jet engine fuels may require a relaxation of current specifications in order to enhance supplies and hold down costs. Problems associated with relaxed specification fuels are luminosity, soot formation, thermal instability, and fuel freezing. All of these problems will continue to be investigated in FY 1980, in coordination with related work on combustors and emissions.

Mechanical components research activity in FY 1980 will continue on evolutionary improvements in the technology of gearing, seals, bearings, lubricants and power transmission shafting. Emphasis will be placed on obtaining a good understanding of the basics of mechanical wear phenomena. This understanding is needed to improve the durability and performance retention of turbomachinery.

Engine improvements require corresponding improvements in measuring techniques. In 1980, this highly sophisticated area will continue to concentrate on high pressure and high temperature measurement techniques, clearance sensing between rotating and stationary machinery, vibration and stress measurements, and gas path flow visualization and measurements.

Low speed aircraft propeller technology, recently revived after many years of dormancy, applies modern aerodynamic, material and structural theory to propeller design to achieve lighter weight, quieter and more efficient small aircraft propellers. In FY 1980, research will be well underway on advanced propeller blade aerodynamic designs.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Air-Breathing Engine Systems Research and Technology.....	8,670	8,800	8,800	8,900

OBJECTIVES AND STATUS:

The objective of the Air-Breathing Engine Systems Research and Technology program is to develop the technology for reducing both the costs and time required for new engine development programs through improved engine systems design and analysis techniques, and the assessment of potential new system concepts.

Investigations in areas such as the effects of distortion on system stability and performance of a high bypass turbofan engine and improvements in stability and combustion efficiency of swirl augmentor concepts will be completed in FY 1979. Calibration of an advanced pressure distortion generator will be completed prior to initial operations with a turbojet engine system. An investigation of thrust transfer performance, using variable inlet guide vanes installed ahead of the fixed pitch fan of a high bypass turbofan engine, will also be completed. An evaluation of Short Take-off and Landing propulsion and airframe system noise will be initiated, utilizing the engines from the Quiet, Clean, Short Haul Experimental Engine activity in combination with typical powered-lift, wing flap configurations.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, research on propulsion control systems will verify the methodology needed to simulate overall performance of advanced aircraft/inlet/turbofan engine systems, and investigate advanced control hardware concepts such as sensors and sensor failure accommodation, signal transmission and severe environment electronics, fault-tolerant propulsion controller, and reliable control software.

Experimental and analytical efforts will be continued in FY 1980 to understand and solve the dynamic interaction problems encountered when engine components are combined to form an engine system. Particular emphasis will be placed on the effects of distortion on overall system stability and performance, and an advanced pressure distortion generator will be introduced into the full-scale research program. Investigations peculiar to small engines and helicopter applications will also be initiated utilizing a small turboshaft engine. Aeromechanical instabilities in fan stages will also be investigated in FY 1980.

The Vertical Short Take-off and Landing (V/STOL) related propulsion work will include analytical and experimental studies of the aerodynamics of engine inlets and nozzle deflectors applicable to these propulsion systems. Evaluation of the system noise of the Quiet, Clean Short Haul Experimental engines when mated with typical power lift, wing flap configurations will be completed.

In FY 1980, hypersonic propulsion research will increase the focus on combustion diagnostics and kinetics-related problems. Improved subscale scramjet modules will be evaluated at Mach numbers 4 and 7.

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Several alternative propulsion concepts to the piston engine are considered to be potantial candidates for future general aviation aircraft applications. The rotary combustion engine and the lightweight diesel, presently judged to be the most promising candidates beyond an advanced spark ignition piston engine, will receive emphasis in FY 1980. Engine conceptual design studies will be conducted, as well as experimental evaluations of key technology areas. Engine/airframe systems studies will be conducted to evaluate overall performance.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Avionics and Flight Control Research and Technology.....	3,985	5,200	5,200	6,200

OBJECTIVES AND STATUS:

The objective of the Avionics and Flight Control Research and Technology program is to support the development of advanced electronics for applications to both civil and military aviation. Major efforts are directed toward enhancing utility, safety and efficiency, while reducing costs, through innovative approaches in the areas of communication, guidance, navigation, control, and displays.

The results of precursory studies of satellite navigation systems and automatic data link systems support the development of the respective systems. Recent improvements in aeroelastic/control analysis will enable the synthesis of more integrated system designs.

BASIS OF FY 1980 ESTIMATE:

Research in the area of digital operations is conducted to provide technology for the design of precise navigation and guidance systems, and automated digital data links which are cost-effective for civil aviation applications. In FY 1980, candidate navigation systems designs will be studied to establish their relative performance and complexity. These studies and experiments are consistent with the planned implementation of the Department of Defense Global Positioning System in the 1980's.

As a result of the in-house assessment, increased emphasis will be placed on advanced display generation and digital processing technology applied to cockpit display and flight management systems. These improved systems will reduce crew workload, improve safety and enhance aircraft management efficiency. Cockpit display requirements will be determined and incorporated into an experimental design for evaluation.

An integrated design of currently independent control functions promises to enhance the efficiency and economics of future aircraft. In FY 1980, preliminary functional requirements for an integrated control design will be defined and associated mechanization concepts will be outlined.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Aircraft Operations and Aviation Safety Research and Technology	4,810	5,500	5,500	6,600

OBJECTIVES AND STATUS:

The objective of the Aircraft Operations and Aviation Safety Research and Technology program is to provide technology which can be used to solve a wide variety of aeronautical safety and safety-related operational problems.

Considerable progress has been made in the past few years in aircraft fireworthiness technology. As a key example, during FY 1978 large-scale test methodologies were developed which offer improved correlation with real fires. Flashover parameters were also established and, through a wide variety of analytical modeling and testing, a much improved understanding of fire dynamics has been obtained. This knowledge gives designers sound options for designs which inhibit fires.

Rheological behavior of antimisting kerosene additives has been investigated, yielding new methods of retaining treated fuel fire safety properties without sacrificing engine combustion efficiencies.

Antiskid systems performance has been examined with a view toward developing improved reliability concepts. Piloted simulation of aircraft operations in ground contact has been developed and enables investigation of control problems in otherwide hazardous operating regimes.

Infrared radiometry has been applied to the clear air turbulence detection and warning problem with encouraging success; the same instrument, with different filters, has shown promise as a wind shear warning instrument.

BASIS OF FY 1980 ESTIMATE:

Expansion of knowledge and understanding of meteorological hazards to aviation is a long-term process. FY 1980 research will include characterization of lightning strikes to aircraft in flight in terms of utilitarian value to aircraft systems designers as they concern themselves with protection of on-board avionics, structural elements, electrical power systems, and propulsion and fuel systems. Severe storms hazards will be characterized through flight penetrations of critical storm regions. Icing meteorological knowledge will be updated.

The advanced digital flight loads measuring equipment effort is to provide hitherto unavailable data on aircraft operation in the terminal area down to touchdown and during landing rollout. Icing tests of new airfoils will be conducted, and optimization of ground and airborne icing environment simulation will be pursued. A new understanding of elastomeric behavior of tires in the landing gear system will be sought.

As a result of the in-house assessment, an increased emphasis will be placed on research into the prevention of aircraft fires and the maximization of fire survivability.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Fluid and Flight Dynamics Research and Technology.....	14,495	16,500	16,500	20,700

OBJECTIVES AND STATUS:

The objective of the Fluid and Flight Dynamics Research and Technology program is to advance understanding of aerodynamic phenomena and improve predictive capability to permit increased performance optimization of advanced aircraft during early design stages.

In the area of computational fluid dynamics, significant advances are being made in the capability of computer codes to predict complicated flow situations and configuration geometries, and in applying the codes to specific analysis and design situations. During the past year, and in cooperation with the aircraft industry, a number of such codes were applied to significantly improve the performance of a number of existing, as well as conceptual, transport and military aircraft. In addition, improvements have been made in these user-oriented codes in terms of efficiency, flexibility, utility and accuracy. Concurrently, significant

progress has been made toward the goal of achieving one-to-one correlation between wind tunnel and full-scale flight data through the elimination of tunnel wall interference effects and through a proper evaluation of the effects of tunnel airstream turbulence on boundary layer transition.

BASIS OF FY 1980 ESTIMATE:

Intensive efforts in computational fluid mechanics will continue in FY 1980. Computer codes will be developed to calculate inviscid and turbulent flows with limited and extensive regions of separation. An efficient user-oriented code will be generated for computing the Navier-Stokes equations for a variety of two and three dimensional geometries on vector processors (including the ILLIAC IV). Techniques will be developed for the simulation of boundary layer transition and turbulence in incompressible and compressible three-dimensional flows.

Future work will include the coupling of potential flow codes with advanced boundary layer codes and the incorporation of flow separation modeling. In the area of high-lift aerodynamics, theoretical methods will be developed to analyze and design multi-element airfoils and wings, and experimental tests will be conducted to verify the analysis. Theoretical research planned includes Reynolds stress modeling of multi-element airfoil drag problems and determination of the effects of transverse pressure gradients on boundary layers and wakes.

Aerodynamic test methods and instrumentation development efforts will continue to stress nonintrusive flow measurements such as holographic interferometry, laser velocimetry and infrared photography to provide data otherwise unobtainable, to improve data collection efficiency, and to gather data in a form more amenable to on-line analysis. Work in the integration of theory and experiment continues with emphasis centering about canard-wing interactions and high incidence forebody vortex flow problems. A major research and technology activity in the fluid and flight dynamics area will be the development of cryogenic technology and full-scale Reynolds number test techniques. This activity will be pursued to insure maximum utilization of the unique capabilities of cryogenic transonic tunnels.

Airframe noise research in FY 1980 will relate the general characteristics of airframe noise to aircraft configuration and operating conditions. Fluid dynamics and acoustics basic research will be conducted in the area of noise generation by turbulent flows. Viscous drag reduction schemes will be evaluated, including slot injection, longitudinal surface striations, and particle injection/recovery.

In the area of flight dynamics, experimental efforts in FY 1980 will be directed toward development of a forced oscillation dynamic stability measurement capability for high angles of attack and high Reynolds numbers. Analytical techniques will be developed for determining stability and control characteristics from flight test data.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Low-Speed Vehicle Aerodynamics and Flight Dynamics Research and Technology	12,700	13,000	13,000	12,600

OBJECTIVES AND STATUS:

The objective of the Low-Speed Vehicle Aerodynamics and Flight Dynamics Research and Technology program is to provide advanced technology to improve the integrated aerodynamic performance, noise, stability, control, and flight dynamics of general aviation aircraft, advanced rotorcraft, and advanced vertical- and short-takeoff and landing (V/STOL) aircraft.

The ability to alleviate poor stall and spin characteristics of some general aviation aircraft through wing modifications, inducing a "flat top" lift curve, was demonstrated successfully, initially by full-scale wind tunnel tests and subsequently verified by flight tests. As part of the ongoing research on reduction of helicopter vibration, initial test results indicate the potential of a large reduction in hub loads through the use of higher harmonic control of blade pitch. In continuing investigations to evolve an effective jet-lift augmentation capability which can be incorporated practically in high performance VTOL configurations, large-scale static and wind tunnel tests were carried out on a complete representative model, in which high augmentation ratios--up to 1.7-- were achieved.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, general aviation efforts will continue to gain a better understanding of the components of drag associated with cooling of the propulsion system to enable improved overall aircraft performance. Further analytical, wind tunnel, and flight tests will be carried out on aircraft configurations having the potential for practical stall immunity and means for spin avoidance.

Rotorcraft research in FY 1980 will include theoretical, small-scale and/or large-scale wind tunnel tests of promising rotor concepts intended to reduce helicopter vibration, including individual blade control, adaptive multicyclic control, active feedback control, and aeroelastically configured rotors. Rotor-hub-pylon fuselage drag reduction studies will continue, initially through small-scale wind tunnel model tests. Development of methods for analyzing three-dimensional rotor flow fields including realistic modeling of viscous and compressibility effects will be initiated. Studies to develop a more complete understanding and prediction of rotor

noise mechanisms will be continued. Initiated in cooperation with the FAA, NASA research helicopters with the capability to vary their stability characteristics will be used in flight investigations to update and refine civil terminal area operation certification criteria.

In FY 1980, in the area of advanced V/STOL aircraft, efforts will be accelerated to improve prediction of cruise and vertical-to-horizontal transition aerodynamics and ground effects with supporting key wind tunnel experiments to guide and verify the analytical approaches being derived. Emphasis will be placed on modeling the propulsion streams to consider propulsion-induced effects and airframe/propulsion system interactions.

	1978 Action	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
High-Speed Vehicle Aerodynamics and Flight Dynamics Research and Technology	11,905	13,000	13,900	14,100

OBJECTIVES AND STATUS:

The objective of the High-Speed Vehicle Aerodynamics and Flight Dynamics Research and Technology program is to generate aerodynamic technology advancements needed to achieve safe, reliable, and economical high-speed civil aircraft and to establish and maintain technological superiority in military vehicles and systems.

The advantages of two-dimensional nozzles for future high performance aircraft have been assessed through studies, and test and simulator evaluations of modified F-15, F-17, and HiMAT aircraft. Results of these tests indicate that two dimensional nozzles offer reductions in drag and weight providing significant improvements in aircraft performance. In thrust vectoring technology, studies and simulation experiments have shown potential for greatly enhanced military mission performance. Hypersonic vehicle research studies continue to show capability for increased performance. Additional potential performance benefits require more realistic plume aerodynamics research, improved performance prediction techniques, and analytical methods for the Mach 6 to 8 flight regime.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The increase of $900 thousand reflects a realignment of funds within the Research and Technology Base to provide increased funds for wind tunnel testing in support of priority high speed research.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, the interactive configuration aerodynamics effort will concentrate on optimizing the interaction of various advanced technologies that can improve overall configuration performance.

The combat vehicle and missile aerodynamic activities will continue to explore selected promising concepts such as noncircular two-dimensional nozzles. Wind tunnel testing of several refined nozzle concepts will be evaluated and the experimental data obtained will be used to evaluate the potential system performance benefits of instantaneous vectoring to enhance maneuverability and increase range through reducing the drag. Advanced aerodynamic concepts applicable to new missile design concepts will be investigated, with emphasis on missile aircraft integration.

The hypersonic aircraft aerodynamics and flight dynamics effort will continue to concentrate on establishing a valid aerothermodynamic data base for future hypersonic vehicle concepts. The activity will include selected hypersonic wind tunnel model tests and tests of subscale components. New methods of testing complete configurations in simulated hypersonic environment will also be investigated.

In FY 1980, as part of interagency and industrial assistance activities, a broad range of experimental investigations, including use of wind tunnels and simulators, augmented with theoretical analyses will be conducted. These efforts will provide support for a broad range of aircraft and missile configurations. As required, joint activities with other Government agencies will be conducted to insure and maintain preeminence of current and future military air vehicles.

The FY 1980 remotely piloted research aircraft technology activities will concentrate on the development of new control concepts for high speed testing and enhancement of pilot control of remotely piloted research vehicles.

Flight experiment support activities will also be conducted to provide a broad base of flight experiments and related efforts applicable to generic problems of high speed vehicles.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Human-Vehicle Research and Technology.....	5,000	5,600	5,600	5,700

OBJECTIVES AND STATUS:

The objective of the Human-Vehicle Research and Technology program is to provide a research and technology base for solutions to the human-factors related problems in influencing the growth, efficiency, and safety of air transportation. The program has three areas of emphasis: flight management, flight simulation technology and human response to noise.

During FY 1979 a number of research studies are being conducted within the major areas. Included are joint programs with the Federal Aviation Administration to enhance aircrew performances and alleviate the potential for human error.

BASIS OF FY 1980 ESTIMATE:

In the flight management area, joint Federal Aviation Administration programs will continue in FY 1980. Studies to assess advanced cockpit warning systems and single-pilot flight operations in advanced air traffic control environments will be initiated. Experimental activities associated with the cockpit traffic information display concept will continue. Work will also begin on the development of models characterizing information processing and decisionmaking processes which are necessary to establish human factors guidelines for automated systems. Studies to assess single-pilot flight operations in advanced air traffic control environments will be initiated.

Flight simulation technology will include efforts to quantify and validate advanced methodologies for conducting large-scale, full-mission simulations. Experimental studies to quantify perceptual models of visual performance in degraded visual environments will continue.

The human response to noise effort will continue to assess the utility of community response models through laboratory and field studies. Improved multiple event noise descriptions will be examined in laboratory settings to establish their validity.

BASIS OF FUND REQUIREMENTS:

SYSTEM STUDIES

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
System Studies	3,000	3,000	3,000	3,200

OBJECTIVES AND STATUS:

System studies are conducted primarily as a means of identifying the need for, and assessing the impact of, technology advances. The objectives of aeronautics system studies are to determine the feasibility, technology requirements, costs, benefits and impacts of advanced civil and military aeronautical systems through mission, system and conceptual design studies. The studies integrate the mutual effects of technology and a wide range of related factors.

Significant recent results include identification of the technology needs of the manufacturers and operators of small "commuter" transport aircraft, quantitative evaluations of the potential impact of technology on future air cargo aircraft and systems, and initial assessments of the applicability of air cushion landing gear and variable wing camber to various aircraft classes.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, studies of civil air transportation systems will emphasize the use of advanced technology for the reduction of operating and acquisition cost of transport aircraft and for the enhancement of airborne systems dedicated to cargo movement. Specific studies will address long-haul air cargo vehicles concepts and their unique technology requirements, small transports for low-density short-haul and commuter use, and future total transportation systems.

Studies of future military aviation systems will be consistent with needs of the military services, with emphasis on vertical takeoff and landing (Navy) and cruise missiles (Air Force).

Studies in FY 1980 of utility aviation systems will emphasize the impact of advanced rotorcraft technology in public service/rescue and heavy-lift helicopters.

Systems analysis methodology and support activities will continue to emphasize air transportation demand, comparisons and integration with other modes, and the understanding of technology transfer processes in the aviation industry.

Studies of general aviation systems in FY 1980 will explore the aeronautical technology needs and opportunities in future general aviation aircraft and propulsion systems.

BASIS OF FUND REQUIREMENTS:

SYSTEMS TECHNOLOGY PROGRAMS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Materials and structures systems technology.....	7,095	4,500	4,500	6,000	9-20
Propulsion systems technology.....	22,150	28,400	28,400	20,600	9-21
Avionics and flight control systems technology.....	1,730	2,400	2,400	1,800	9-23
Aircraft operating systems technology.....	7,020	9,300	9,300	11,700	9-24
Aerodynamic vehicle systems technology.....	3,740	5,600	5,600	10,500	9-25
Human-vehicle systems technology.....	800	800	800	400	9-27
Advanced civil aircraft systems technology.....	21,700	20,400	18,340	28,520	9-27
High-performance aircraft systems technology.....	9,000	9,000	11,060	16,580	9-29
Rotorcraft systems technology.....	2,530	5,245	5,245	10,000	9-31
Total.....	75,765	85,645	85,645	106,100	
Materials and Structures Systems Technology.....	7,095	4,500	4,500	6,000	

OBJECTIVES AND STATUS:

The objective of the Materials and Structures Systems Technology Program is to accelerate the transfer of advanced materials and structures technologies to application in the design of aircraft structures and engines.

In the Materials for Advanced Turbine Engines (MATE) effort, directionally solidified eutectic turbine blades completed their 150-hour Federal Aviation Administration qualification test and will be on the bill of materials for the widely used TFE 731 general aviation engine. Single-crystal turbine blades are currently being produced for engine testing.

In the Aeroelasticity of Turbine Engines (ATE) activity, significant progress has been made in developing analyses to predict supersonic flutter and stall flutter of turbine blades and flutter boundary mapping of fan blades.

The Fire Resistant Materials Engineering (FIREMEN) effort has developed new resins, foam fillers and adhesives with vastly improved flammability resistence and low smoke and toxic gas yields.

BASIS OF FY 1980 ESTIMATE:

The MATE effort involves the identification of promising high temperature materials for production and development of engineering data followed by engine testing. During FY 1980, the emphasis will be on demonstrating the performance of single-crystal turbine blades, an advanced powered metallurgy disk, an advanced directionally solidified turbine blade, and an advanced turbine blade tip seal. The goal is to reduce the specific fuel consumption in engines by 1.5 percent using these materials.

The Integrated Program for Aerospace Vehicle Design (IPAD) efforts in FY 1979 will evaluate the complex software requirements for the system. In FY 1980, the detailed design of all first-level software components will be completed, and the preliminary version of the data base management system will be released for industry evaluation.

The ATE technology activity is a joint Air Force/NASA effort to improve the understanding and prediction capability for aeroelastic instability phenomena in turbine fan stages. The FY 1980 effort includes correlation of analytical predictions with experiments on the vibratory modes of blade, shroud, and disk systems of advanced fans and compressors and completion of the development of a prediction technique for blade flutter.

The FIREMEN activity was designed to accelerate the development of fire-resistant, low toxicity polymers for use in commercial aircraft. In FY 1980, evaluation of materials systems developed earlier will continue. In particular, tests of materials used in panels, enclosures, windows, seat fabrics, moldings and cushioning will provide data needed by designers. Selections can then be made for the safest combinations of materials to help resist fire, smoke and toxic gases.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Propulsion Systems Technology.....	22,150	28,400	28,400	20,600

OBJECTIVES AND STATUS:

The objective of the Aeronautical Propulsion Systems Technology program is to achieve increased performance and efficiency of the complete propulsion system through integration of advanced propulsion components.

In the Engine Component Improvement activity, all performance improvement concepts for the JT8D, JT9D and CF6 engines are under development. In the Variable Cycle Engine Components effort, the noise reduction benefit of coannular nozzles has been verified in full-scale tests.

BASIS OF FY 1980 ESTIMATE:

The Helicopter Transmission Systems Technology efforts will provide a systems evaluation of many advanced technology components which have been under investigation for a number of years. Design work on an advanced technology gear-type transmission and a traction-drive transmission was completed, and in FY 1979 these designs were translated into test articles. In FY 1980, these two transmissions will undergo performance testing.

The Broad Specification Fuels Technology activity is aimed at demonstrating the compatibility of broad specification fuels, which were defined and characterized in the Research and Technology Base, for operation in current and next generation commercial jet engines. Combustor design definition and conceptual evaluation are currently underway. In FY 1980, the combustor design requirements and criteria will be completed.

The Variable Cycle Engine (VCE) Components effort will continue to evaluate advanced technology components which offer significant performance benefits combined with reduced noise and emission characteristics. During FY 1980, the last year of funding for this activity, the focus will be on the aero/acoustic performance and component interactions and compatibility of a core-driven third-stage fan and an outer-stream jet suppressor operating in conjunction with a coannular plug nozzle. The operational and emission characteristics of an advanced, less complex duct burner configuration will also be investigated.

In the Engine Component Improvement effort, detailed technical and economic feasibility analyses of potential performance improvement concepts were completed in FY 1978. Development has been initiated on the seventeen most promising technology concepts. In FY 1980, the last year of funding for this activity, component rig tests, engine ground tests and flight tests will be conducted to evaluate the selected design concepts, which can then be promptly introduced into production engines to reduce fuel consumption on the order of 5 percent in current commercial transports. Several near-term fuel-saving concepts have already been selected for incorporation in the CF6 and JT9D engines which will power the new Boeing 767 transport aircraft. Development work will continue in engine diagnostics technology to identify and quantify the causes of

performance deterioration. Component sensitivity studies will be conducted, based on historical and test data compiled earlier. Analytical models and correlations will be developed to aid in the analysis of deterioration in existing engines, as well as in the design of future engines.

The Stratospheric Cruise Emission Reduction effort establishes and demonstrates the technology necessary to reduce exhaust emissions from modern gas turbine aircraft engines to environmentally acceptable levels over the entire subsonic flight envelope, with minimum adverse effects on performance, weight and complexity. Special emphasis is being placed on reductions in stratospheric cruise emissions of oxides of nitrogen. The assessment of promising combustion system concepts will be completed in FY 1979. In FY 1980, experimental evaluations of the most promising concepts will be completed. These concepts will have as a major goal an emission level of 3 grams of nitrogen oxide per kilogram of fuel at cruise conditions. This value represents a tenfold reduction compared to current production engines.

The Advanced Turboprop program will provide the technology necessary for advanced high-speed propellers capable of providing up to 25 percent fuel savings relative to current high-bypass-ratio turbofan engines. In FY 1980, the design and fabrication of a propeller model optimized for aerodynamic, acoustic and structural considerations will be completed. Flight tests will be conducted with a Jet Star aircraft to assess the near-field acoustic characteristics of an advanced propeller model. The development of fuselage noise attenuation concepts selected from an experimental screening process will continue. The absolute level of propeller slipstream/wing interference drag will be established for a specific configuration. Analytical evaluations will be made of potential aircraft, engine and propeller drive system mechanical components.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Avionics and Flight Control Systems Technology.....	1,730	2,400	2,400	1,800

OBJECTIVES AND STATUS:

The objective of the Avionics and Flight Control Systems Technology program is to apply the fundamental knowledge gained in the Research and Technology Base to demonstrate technology readiness and to promote the transfer of advanced avionic systems techniques to the aircraft industry through experimental testing and verification in a realistic environment.

In the Digital Fly-by-Wire program, flight evaluation of an adaptive control law is underway which will permit system adaptation to changes in flight conditions. In the General Aviation Advanced Avionics Systems program, the selection of the conceptual system design has been made and a contract initiated to fabricate an evaluation model.

BASIS OF FY 1980 ESTIMATE:

The Digital Fly-by-Wire activity provides for development and evaluation of an all electronic, redundant aircraft flight control system in an actual flight environment.

The principal emphasis is on reduced weight and fuel consumption, and on improved performance and operational flexibility. In FY 1980, flight evaluations of a failure management system will be completed and preliminary ground tests conducted to analyze the susceptibility of advanced digital avionic systems to lightning.

The General Aviation Advanced Avionics Systems effort is aimed at providing a totally integrated, advanced, low cost avionics system to enhance the safety, reliability, and utility of future general aviation aircraft. During FY 1980, a model of a conceptual system design will be fabricated and system evaluation tests initiated.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Aircraft Operating Systems Technology.....	7,020	9,300	9,300	11,700

OBJECTIVES AND STATUS:

The objectives of the Aircraft Operating Systems Technology program are to demonstrate and evaluate advanced integrated aircraft system concepts for navigation, guidance, control, and cockpit displays which are technically advanced with substantial improvement in system architecture and capability to meet the performance demands of future air traffic control (ATC) systems. This technology effort involves analytical studies, simulations, and application of advanced technology through the hardware-flight test phase to reduce risk to the point where the technology will be accepted and applied to future aircraft configurations for safer and more productive flight operations. The effort is carried out utilizing the advice and cooperation of the airlines, aviation industry, and the FAA.

Emphasis in FY 1979 is being placed on air-carrier transport-type aircraft (B-737) and rotorcraft (UH-1H, CH-47), and XV-15 Tilt Rotor Research Aircraft) equipped with advanced displays and integrated digital avionics systems which are dedicated to experiments that explore efficient descent and approach paths, landing in adverse weather, precision flight path control, and interfaces between the pilot and the ATC system.

BASIS FOR FY 1980 ESTIMATE:

Operating system technology studies will address, in a joint effort with FAA, problems and promising methods for certification of advanced digital flight control systems. Piloted, real-time mission simulations using representative actual flight hardware and software will be conducted to evaluate system reliability and fault tolerance. Studies will also be performed to identify the potential application of advanced technology to the safe operation of single-pilot general aviation aircraft in adverse weather.

In close coordination with the FAA, the Terminal Configured Vehicle (TCV) research activities in airborne systems and operational procedures will be aimed at adding capacity to the ATC system, supporting ATC system evolution, maximizing utilization of congested airspace, improving capability in adverse weather, and improving fuel conservation. Investigations of the capacity, efficiency, and safety potential of Cockpit Display of Traffic Information (CDTI) with elements envisioned for use in the 1985-1995 ATC systems will be stressed in FY 1980.

In a joint effort with the Army and the FAA, the Rotorcraft Operating Systems program will demonstrate new technology applied to instrument flight rules (IFR) flight operations for civil and military rotorcraft.

This activity will include instrument meteorological condition landings using advanced guidance, control and displays; definition of ATC concept and operational procedures for medium-density operations to closely spaced oil rigs; and exploration of concepts and development of self-contained navigation and guidance concepts for IFR approaches to remote sites.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Aerodynamic Vehicle Systems Technology.....	3,740	5,600	5,600	10,500

OBJECTIVES AND STATUS:

The objective of this program is to investigate the potential application of improved aerodynamic concepts to existing or future aerodynamic vehicle systems and to demonstrate, in flight, selected concepts that show particular promise for improving aircraft performance, efficiency, safety, utility and operating effectiveness.

The feasibility of reducing the safe takeoff and landing separation distance between aircraft in the presence of trailing wake vortices to three miles or less has been indicated by coordinated laboratory and flight investigations conducted under the Wake Vortex Minimization program. A number of promising aerodynamic concepts to reduce the generation of wake vortices have been identified, but a fundamental understanding of the phenomena does not yet exist.

The second phase of the Laminar Flow Control (LFC) activity, a validation of LFC concepts and configurations, was initiated in FY 1979. This phase will expand the technology development to provide added focus on key areas such as aerodynamics, structures, and suction systems. A contract will be awarded during FY 1979 to modify a suitable aircraft for a leading-edge glove flight test to demonstrate laminar flow compatability with supercritical airfoils under actual flight conditions which cannot be simulated in the wind tunnel.

BASIS OF FY 1980 ESTIMATE:

In the Wake Vortex Minimization, the FY 1980 activity will emphasize fundamental studies to determine aerodynamic design factors that influence the formation and destructive interference of multiple vortex systems. A generalized wind tunnel model will be used to relate wing geometry to the near-field vortex flow characteristics and to provide input data to computational techniques which will be used to provide aircraft designs optimized for minimum wake vortex effects.

In Laminar Flow Control, efforts will continue to develop the technology required for a practical, reliable, and easily maintained system. In FY 1980, contracts will be awarded for the detailed design and test of two wing box structural concepts, including outer cover panels and related ducting. Wind tunnel tests will be conducted on a swept-wing supercritical airfoil to investigate boundary layer control and flow laminarization by using suction through wing surface slots. Work will continue toward modification of a small aircraft with a wing glove for flight evaluation of laminar flow control/supercritical airfoil compatibility.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Human-Vehicle Systems Technology.....	800	800	800	400

OBJECTIVES AND STATUS:

The objectives of this program are to reduce the frequency of aviation incidents and accidents attributable to human error and investigate techniques and operational procedures that will ensure optimum performance in multicrewmember aircraft, and to continue to operate an Aviation Safety Reporting System (ASRS) at the request of the Federal Aviation Administration.

In FY 1979, investigations are being conducted to identify information transfer deficiencies between air and ground personnel. Analytical and experimental methods for assessing the safety contribution of new procedures and systems and the effectiveness of full mission simulation as a training technique are under investigation. A computer-based data management system is being used to aid in the analysis of safety reports. Emphasis is being placed on analysis of factors contributing to air crew and controller error.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, full mission simulation studies will be continued examining solutions to information transfer and decision-making problems encountered during complex flight phases. Operation of the Aviation Safety Reporting System will be continued into FY 1980. In late FY 1980, FAA and NASA will give consideration to continuation, transfer to FAA or termination of this reporting system. In addition, new research investigations, based on the problems identified from ASRS data, will be initiated.

Advanced Civil Aircraft Systems Technology.....	21,700	20,400	18,340	28,520

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OBJECTIVES AND STATUS:

The objectives of the Advanced Civil Aircraft Systems Technology program are to provide a technology base for the design and operation of advanced transport and special-purpose civil aircraft, using promising technologies generated in the Research and Technology Base program, and to exploit military-developed aircraft and technologies for civil applications.

In the Energy Efficient Transport (EET) activity, contracts for the second phase effort were awarded during FY 1979 to continue advanced aerodynamics and active controls technology programs by three major airframe manufacturers. The L-1011 aircraft wing tip extension/active controls flight tests were completed. These tests evaluated maneuver load control, elastic mode suppression, gust load alleviation, and aircraft performance. Modifications to the KC-135 airplane will be completed and winglet flight tests initiated. Test and evaluation of a fault-tolerant computer engineering model will be conducted during FY 1979, and NASA wind tunnel tests for advanced aerodynamics technology and parametric controls model evaluation will continue.

In the Quiet, Propulsive-Lift Systems Technology efforts, an analysis was conducted to establish characteristics of advanced flight control and display concepts for improving terminal area flight control and handling qualities. Flight experiments will be continued during FY 1979 with Augmentor Wing and Twin Otter Research Aircraft, exploring applicability of the microwave landing system to STOL operations, and alternate digital avionics functional configurations and terminal area operational concepts. Work has been initiated to define specific Quiet Short-Haul Research Aircraft (QSRA) flight experiments which will provide a data base for improved powered-lift flying qualities criteria and flight control systems.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease of $2,060 thousand reflects a transfer of the vertical takeoff and landing (VTOL) Systems Technology activity to the High-Performance Aircraft Systems Technology program.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, studies will be conducted to investigate the applications of advanced technology to advanced civil passenger and cargo transport in such a way as to decrease initial acquisition and recurring operating costs while maintaining safety, maintainability and environmental compatibility.

In the second phase of the Energy Efficient Transport (EET) effort, work will continue with major airframe contractors to develop, refine, and evaluate advanced aerodynamic and active control technologies for near-term and future application to derivative and new subsonic transport aircraft. In FY 1980, advanced winglet

concepts will be wind tunnel tested to establish cruise aerodynamic performance and basic wing and high lift system/high Reynolds number models will complete wind tunnel evaluation of low-speed aerodynamic characteristics. Aeroelastic wing/flight control system wind tunnel tests will be completed and flight tests initiated. In the area of high reliability/high maintainability flight controls, advanced computer evaluations will continue, and data distribution system architecture evaluation studies will be completed.

The Quiet, Propulsive-Lift Systems Technology efforts will complete NASA participation in the USAF Advanced Medium STOL Transport (AMST) program to obtain handling qualities and flight systems performance data for establishing civil certification criteria for powered-lift aircraft with a maximum lift coefficient of 3.5. Terminal area flight operations research with the Augmentor Wing aircraft and STOLAND digital avionics research system will be completed. Documentation of the QSRA baseline flight characteristics will be completed in preparation for future flight research experiments which will include systems investigations to enhance the design data base for efficient all-weather terminal area operations and the expansion of the certification criteria data base.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
High-Performance Aircraft Systems Technology.....	9,000	9,000	11,060	16,580

OBJECTIVES AND STATUS:

The objective of the High Performance Aircraft Systems Technology program is to perform the extensive research, including wind tunnel, ground-based simulator and flight tests, required to generate engineering and design data applicable to advanced high-performance, high-speed aircraft for civil and military applications.

The vertical takeoff and landing (VTOL) Systems Technology program will establish a broad technology base for anticipated and potential military and civil VTOL applications involving high-speed cruise flight. Emphasis has been placed on analytical and simulator investigations, tests of advanced propulsion concepts, and wind tunnel studies of advanced configurations. The Supersonic Cruise Research program continued the detailed study of high potential technologies in aerodynamics, propulsion, structures and materials fabrication. A major effort was also directed to technology associated with the integration of the recently acquired variable-cycle engines data with the advanced inlets, the coannular nozzles, the nacelle and various airframe platform configurations. Advanced flight investigations continue in the areas of airframe/propulsion

integration, the mission adaptive wing and high angle-of-attack research. In FY 1979, airframe/propulsion integration investigations are being conducted with the F-15 aircraft to provide basic performance information. In the joint NASA/Air Force mission adaptive wing effort, initial wind tunnel testing has identified the potential for large performance gains for fighter aircraft over the entire flight envelope using variable camber and variable sweep. In the joint NASA/Navy high angle-of-attach experiments, a NASA developed aileron-to-rudder interconnect system has been evaluated in ground simulation and appears to exhibit a potential solution to the recurring F-14 high angle-of-attack controllability problem.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The increase of $2,060 thousand reflects a transfer of the vertical takeoff and landing (VTOL) System Technology activity from the Advanced Civil Aircraft Systems Technology program.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, the VTOL Systems Technology program will be directed to configuration aerodynamics concepts to be evaluated in both subsonic and supersonic wind tunnel tests, a large-scale model tests in the 40 by 80-foot wind tunnel, and a large-scale deflectable nozzle to be tested with both subsonic and supersonic experimental propulsion systems on a static test stand to determine criteria for deflecting thrust through 90°. These efforts will complement ongoing efforts in ship motion/aircraft flight control studies, configuration definition and refinement with advanced propulsion concepts.

During FY 1980, the Supersonic Cruise Research efforts will emphasize refinement of aerodynamic configurations over the full operational speed range using analytical techniques coupled with an extensive wind tunnel testing program, improved inlet designs and installation studies for variable-cycle engines, advanced nozzle concepts including coannular configurations with suppression, the integration of the propulsion system/nacelle to the airframe, and the continuation of advanced titanium structures design and fabrication techniques.

The FY 1980 Advanced Flight Experiments efforts will continue research into airframe propulsion integration emphasizing testing of new information and control concepts for advanced aircraft. Following the phase-out of the YF-12 research aircraft, the F-15 will be utilized to integrate advanced controls for engine, inlet and aircraft guidance to maximize performance at all flight conditions and to reduce pilot workload. The ongoing joint effort with the Air Force in FY 1980 will be directed to the design and construction of a mission adaptive wing for the F-111 aircraft. This program is an attempt to combine, in an actual wing, the variation in sweep angle with in-flight variations in wing camber to achieve and demonstrate maximum performance over the full operational speed range of the aircraft. In FY 1980, the Advanced Flight Experiments activity also will continue the NASA/Navy high angle-of-attack flight experiments using an F-14 aircraft to investigate the interconnect system.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Rotorcraft Systems Technology.....	2,530	5,245	5,245	10,000

OBJECTIVES AND STATUS:

The objective of the Rotorcraft Systems Technology effort is to conduct broad-based research on promising rotorcraft systems for use in future civil and military applications. The major areas of concern are rotorcraft structural systems; propulsion; guidance, control and navigation; advanced rotor system concepts; and advanced concepts for vibration and noise reduction. The activity involves coordinated research efforts in analysis, model testing, simulation, large-scale wind tunnel testing and flight testing of rotorcraft and subsystems. A key element is the verification of analytical design methods by ground-based and in-flight experiments.

The two new Rotor System Research Aircraft (RSRA) vehicles are being brought to a state of readiness for research flight investigations. Substantial progress is being achieved in concentrating the NASA experimental rotorcraft and associated test support equipment at the Ames Research Center.

BASIS OF FY 1980 ESTIMATE:

A major effort will essentially complete the incorporation and checkout of the flight test capabilities planned for the RSRA vehicles and provide comprehensive flight test data on the delivered rotor system in both the helicopter and compound flight modes. Efforts will begin in FY 1980 to enhance the capability of the newly acquired Vertical Motion Simulator to perform effective, high fidelity rotorcraft simulations to develop criteria for improved design and piloting quality criteria. Modifications will begin on existing helicopter rotors which can be readily adapted for flight test on the RSRA, and which would benefit significantly from the expanded test envelope capability of this research vehicle. Conceptual and preliminary design studies will be initiated for a general purpose research rotor, which may lead to the first new rotor for far-term investigation on RSRA.

The XH-59A helicopter incorporating the Advancing Blade Concept will be tested in the Ames Research Center 40 by 80-foot wind tunnel to assess potential for drag reduction and to correlate flight test data obtained in a joint Army/Navy/NASA program. The performance and loads of a new bearingless full-scale rotor will be evaluated in the tunnel.

BASIS OF FUND REQUIREMENTS:

EXPERIMENTAL PROGRAMS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Energy efficient engine	18,500	43,150	43,150	55,600	9-32
Highly maneuverable aircraft technology	2,480	1,500	800	1,500	9-33
Composite primary aircraft structures	25,150	20,000	20,000	16,400	9-34
Quiet, clean, short-haul experimental engine	600	105	105	---	9-35
Tilt rotor research aircraft	2,300	500	500	---	9-35
Quiet propulsive-lift technology	2,400	1,000	1,700	---	9-36
Total	51,430	66,255	66,255	73,500	
Energy Efficient Engine	18,500	43,150	43,150	55,600	

OBJECTIVES AND STATUS:

The Energy Efficient Engine (EEE) program is directed toward the development and demonstration of the technology for achieving significant reductions in both specific fuel consumption and direct operating cost in future turbofan engines.

The EEE preliminary design and integration studies, completed in January 1978, established the engine cycle and configuration characteristics around which the subsequent Component Development and Integration phase of the program was structured. This phase was initiated early in 1978 with contract awards to the General Electric Company and the Pratt & Whitney Aircraft group of United Technologies Corporation. The preliminary design of the EEE flight propulsion systems, a major program milestone that establishes the configuration baseline for all component and subsystem interfaces, has been completed. Initial experimental efforts on several components have verified efficiency goals and substantiated design approaches.

BASIS FOR FY 1980 ESTIMATE:

Detailed aerodynamic and mechanical design, subcomponent rig testing, fabrication of core and integrated core/low spool components and testing of core components will be the dominant activities in FY 1980. Core components will be fabricated and tested in full scale to demonstrate performance. The core engine system will be designed, fabricated, assembled and tested. Modifications will be made to the core by incorporating new technology from parallel component development work. All available technologies will be integrated and demonstrated in a core/low spool system test.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Highly Maneuverable Aircraft Technology.....	2,480	1,500	800	1,500

OBJECTIVES AND STATUS:

The objective of this joint effort with the Air Force is to provide low-cost flight research vehicles to promote and stimulate the application of new high-risk (laboratory) technology for the design of future vehicles. The program will provide two unmanned, subscale, remotely piloted, low-cost flight research vehicles which will be extensively flight tested. The flight test program will concentrate on the key new technologies incorporated into the Highly Maneuverable Aircraft Technology (HiMAT) design, advanced airfoils with close coupled canards, and aeroelastic tailoring.

Both research vehicles have been fabricated and delivered to NASA, and are undergoing preflight checkouts. The first flight is scheduled for June 1979.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease reflects rephasing between HiMAT efforts and the Quiet Propulsive Lift Technology efforts in FY 1978/1979. HiMAT efforts were increased toward the end of FY 1978 by offsetting adjustments in the Quiet Propulsive Lift Technology activity.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, the flight research activities will address the vehicle test envelope definition and the verification of the basic design methodology. Approximately eight flights are planned to explore the performance envelope of the HiMAT vehicles.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Composite Primary Aircraft Structures.....	25,150	20,000	20,000	16,400

OBJECTIVES AND STATUS:

The objective of the Composite Primary Aircraft Structures program is to develop the technology needed to assure early use of advanced composite materials in future transport aircraft. The weight savings attainable with composites can result in a 10-15 percent fuel savings. The cost economy and long-term reliability and maintainability of composites will be demonstrated by designing, fabricating, testing, certificating and installing composite components on scheduled airline aircraft.

The DC-10 rudder effort is now complete, and Douglas is considering incorporation of the composite component into production of future aircraft. The B-727 elevator program is now in the full-scale component test phase and will be completed in FY 1979. The other four components (DC-10 vertical stabilizer, L-1011 aileron and vertical stabilizer, and B-737 horizontal stabilizer) are in the design and manufacturing development phase. The preliminary wing design studies are complete, indicating a potential 25-percent weight saving and a 15-percent fuel saving for a new design. Interim results of the risk assessment of accidental release of carbon fibers from aircraft indicate the risks to be lower than originally estimated. Final results of the risk assessment will be available in FY 1980.

BASIS OF FY 1980 ESTIMATE:

Four of the six component activities will continue in FY 1980. The manufacturing development will be completed for the DC-10 vertical stabilizer and full-scale test components fabricated. The component tests for the B-737 horizontal stabilizer will be completed, and five flightworthy units fabricated; manufacturing development and ground tests for the L-1011 aileron and vertical stabilizer will be completed; and the carbon fiber release risk assessment will involve fire testing of full-scale aircraft structures. Further development of modified matrix and fiber materials will also be continued to minimize carbon fiber release.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Quiet, Clean, Short-Haul Experimental Engine.....	600	105	105	---

OBJECTIVES AND STATUS:

The objective of the Quiet, Clean, Short-Haul Experimental Engine (QCSEE) program is to consolidate and demonstrate the technology needed for very quiet, clean and efficient propulsion systems for economically viable and environmentally acceptable powered-lift, short-haul aircraft. The QCSEE program includes the design, fabrication and testing of two experimental turbofan propulsion systems, suitable for "under-the-wing" and "over-the-wing" externally blown-flap powered-lift aircraft installations.

The "over-the-wing" and "under-the-wing" propulsion system test activities at the General Electric Company test facility were completed in June and July 1978, respectively. These tests verified achievement of the major noise reduction goals for QCSEE. Many other advanced technology features such as a variable pitch composite fan, a lightweight integrated composite nacelle, gear reduction drives and integrated digital controls were also successfully demonstrated during these tests. Contractor efforts for design, fabrication, test and delivery of the propulsion systems to NASA were successfully accomplished.

Tilt Rotor Research Aircraft.....	2,300	500	500	---

OBJECTIVES AND STATUS:

The objective of the joint Army/NASA Tilt Rotor Research Aircraft (TRRA) program is to design, fabricate and flight test two research aircraft and to perform a proof-of-concept flight program to verify tilt rotor technology for application to the design and operation of civil and military aircraft. One of the primary objectives is to verify rotor/pylon/wing aeroelastic stability over the entire operational envelope. This program is based on a series of research and technology activities which began with the XV-3 tilt rotor flight tests in the 1950's.

The first of two XV-15 tilt rotor aircraft was delivered to Ames Research Center in March of 1978 for full-scale tests in the 40 by 80-foot wind tunnel. The tests were completed in June 1978 with all dynamic systems operating satisfactorily to speeds of 180 knots. Stable rotor/pylon/wing aeroelastic coupling

predictions were verified. Vehicle drag was somewhat higher than expected and a tail buffet problem was uncovered and documented at speeds of approximately 80 to 100 knots. Solutions have been identified and the problem will be corrected in FY 1979.

The second of the two aircraft has completed ground tie-down tests and is in final preparation for contractor flight tests at Bell Helicopter Textron. This aircraft will be delivered to the NASA in FY 1979 and proof-of-concept flight program will begin in the fourth quarter of FY 1979 and will be continued throughout FY 1980. Funding for operational tests will be covered under the Aircraft Operating Systems Technology Activity in FY 1980. The flight testing will be conducted by a joint Army/NASA Project team. After the Government flight tests, the TRRA will be used as a facility for advanced technology flight tests.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Quiet Propulsive-Lift Technology.....	2,400	1,000	1,700	---

OBJECTIVES AND STATUS:

The objective of the program is to generate and verify a design and certification technology data base for efficient, quiet, short-haul transports with short takeoff and landing capabilities. Propulsive lift offers the most effective means of accomplishing this objective and offers potential for airport congestion relief, community noise reduction and operational improvements for civil and military transports. Research includes experiments in aerodynamics, propulsion, handling qualities, noise, flight control systems, information displays and operations.

The Boeing Commercial Airplane Company completed the design of the Quiet Short-Haul Research Aircraft (QSRA) in August 1977. Aircraft fabrication and assembly were completed in February 1978. The first flight of this research aircraft was accomplished in July, followed by delivery to NASA and initiation of proof-of-concept flights in August 1978. In FY 1979, the proof-of-concept flight tests will be completed.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The increase of $700 thousand reflects rephasing between the FY 1979 Quiet Propulsive-Lift Technology efforts and the FY 1978 Highly Maneuverable Aircraft Technology experimental requirements. The total funding for Quiet Propulsive-Lift Technology has not changed.

SUMMARY:

After the completion of the Quiet Short-Haul Research Aircraft's proof-of-concept flight tests in FY 1979, this unique research vehicle will be available for use in technology investigations to be conducted in the Advanced Civil Systems Technology activity.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Research and technology base	65,505	71,700	71,795	77,100	10-3
System studies	2,000	2,000	2,000	2,200	10-16
Systems technology programs	5,800	7,900	7,900	16,000	10-18
Experimental programs	15,395	17,700	16,605	18,100	10-21
Standards and practices	9,000	9,000	9,000	3,000	10-22
Total	97,700	108,300	107,300	116,400	
Distribution of Program Amount by Installation:					
Johnson Space Center	4,499	5,300	5,001	9,440	
Marshall Space Flight Center	6,846	7,500	8,801	6,500	
Goddard Space Flight Center	5,303	8,800	7,539	9,300	
Jet Propulsion Laboratory	24,051	23,300	25,018	24,600	
Ames Research Center	8,563	9,700	10,007	9,840	
Dryden Flight Research Center	40	---	---	---	
Langley Research Center	25,132	22,700	25,287	27,400	
Lewis Research Center	19,028	26,600	22,335	25,420	
Headquarters	4,238	4,400	3,312	3,900	
Total	97,700	108,300	107,300	116,400	

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Space Research and Technology program are to provide the technology base necessary to support current and future space activities; to formulate technology options for the future; and to advance approaches for further reducing the costs of space activities.

The FY 1980 program supports these objectives by stressing the technology areas judged to be most critical by advisory groups, a special in-house assessment, and in-house users of the technology. The program is designed to develop the technology needed to enhance planned missions and to enable future missions which are beyond current capabilities, with emphasis on increasing performance and reducing cost and risk in the areas of information systems, spacecraft systems, power systems and transportation systems. When required, the program demonstrates the readiness of new technology to assure its acceptance for utilization on planned missions.

CHANGES FROM FY 1979 BUDGET ESTIMATES:

The decrease of $1 million reflects the Space Research and Technology portion of the Congress' general reduction in NASA's FY 1979 appropriations request.

BASIS OF FUND REQUIREMENTS:

In FY 1980, a strong research and technology effort will be maintained in the disciplinary areas of materials, structures, sensing and detection, guidance and control, data reduction and distribution, chemical and electric propulsion, space energy systems and aerothermodynamics to meet the needs of current and future space activities. Systems Studies will be pursued to investigate future space mission alternatives and to identify and evaluate the technology requirements of future missions.

Systems Technology efforts will emphasize extending the temperature limits for composite materials to allow their use on advanced space transportation systems; providing advanced technology in materials, structures, assembly, and controls for potential future NASA space missions; definition of system requirements, configurations and techniques for efficient and timely transfer of space acquired data to the user community while

reducing costs; and demonstration of the technology readiness of an advanced planetary orbiter spacecraft propulsion system which utilizes high-performance, space-storable, fluorine-hydrazine propellants. In addition, emphasis will be placed on developing the technology for advanced space communication systems.

In the Experimental programs, under the Space Technology Shuttle/Spacelab program, experiments will be integrated with the Long Duration Exposure Facility (LDEF) and the LDEF will be ready for integration with the Shuttle. The development and integration of experiments to be conducted on early Shuttle and Spacelab missions will be continued. The development and integration of experiments which will utilize the Shuttle orbiter as a research vehicle to conduct multidisciplinary research will also continue.

In the standards and practices area, emphasis is being placed on completion of standard hardware for use on multiple missions, product improvement through component upgrading, and on improvement of program practices, concentrating on such areas as specifications, testing and flight project analysis.

BASIS OF FY 1980 ESTIMATE:

RESEARCH AND TECHNOLOGY BASE

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Materials research and technology	7,100	7,500	7,500	7,800	10-4
Structures research and technology	6,000	7,200	7,200	7,700	10-5
Sensing and detection research and technology	4,400	4,950	4,895	5,400	10-6
Guidance and control research and technology	3,500	3,850	4,000	4,300	10-7
Data reduction and distribution research and technology	6,500	8,300	8,300	9,700	10-8
Chemical propulsion research and technology	8,100	9,200	9,200	9,900	10-10
Electric propulsion research and technology	6,300	7,000	7,000	7,500	10-11
Space energy systems research and technology	9,600	11,200	11,200	11,900	10-12
Nuclear energy research and technology	1,200	---	---	---	10-13
High power lasers and energetics research and technology	6,500	6,700	6,700	6,800	10-14
Entry research and technology	6,305	5,800	5,800	6,100	10-15
Total	65,505	71,700	71,795	77,100	

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Materials Research and Technology.....	7,100	7,500	7,500	7,800

OBJECTIVES AND STATUS:

The objective is to provide advanced materials technology for the development of efficient, economical structural materials, lubricants, seals, and thermal protection materials for advanced space power and transportation systems, space structures, orbiting spacecraft and planetary probes.

Most superalloys with potential for use in space power systems are significantly degraded during long vacuum exposure at high temperatures. The maximum use temperature, therefore, is about 800°C. Some advanced alloys offer potential for use at higher temperatures. Studies of adhesion, friction, and wear are continuing. Boron/aluminum composites have been manufactured and are undergoing evaluation. Advanced seals and lubricants have been designed and are also being evaluated. Several heat shield materials have been developed and are being evaluated for application to advanced space transportation systems.

BASIS OF FY 1980 ESTIMATE:

Basic research activities in FY 1980 will include corrosion, chemisorption, catalysis, hydrogen embrittlement, fiber-matrix interface properties, and lifetime prediction in elastomeric systems. An improved understanding of these phenomena and processes will provide the foundation for improving performance of aerospace materials. In FY 1980, increased attention will be given to the effect of the space environment of the properties of composite materials. Materials which have good long-term resistance to space radiation will be identified. The upper use temperature for commercially available superalloys in vacuum will also be determined. Liquid and solid lubricants will be studied for their stability at high temperatures and in vacuum. High-pressure seal concepts will be evaluated in a simulated turbopump. Studies will continue to identify the most efficient heat pipe materials, working fluids, designs and processing methods to produce economical heat pipes.

Thermal protection concepts and materials are being evaluated for the protection of re-entry vehicles and planetary probes. In FY 1980, emphasis will be on obtaining better understanding of the creep of high-temperature alloys for hot structures. For insulating heat shields, the emphasis will be on evaluating refractory fibers capable of withstanding temperatures as high as 3500°F. Heat shield materials for planetary and solar probes will also be developed and tested to evaluate their performance.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Structures Research and Technology.....	6,000	7,200	7,200	7,700

OBJECTIVES AND STATUS:

The objectives of this program are to provide advancements in current structural technology needed to promote improved performance, durability and economy in future space systems design and to develop advanced structural concepts, design, and qualification procedures to enable development of new systems with operational requirements well beyond the current state of technology.

The "Shock Spectra" method of dynamic loads prediction being developed for use in the initial design stages of payloads has been successfully verified using the Viking spacecraft flight data. Deployable platform truss configuration studies have been completed and a ground test program to verify deployment dynamics predictions is in progress. Plans have been completed for experimental evaluation of a concept for joint configuration and assembly of erectable platforms.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, the research and technology efforts will continue to evaluate selected structural concepts for deployable and erectable space systems and to establish design and qualification procedures required to meet possible future mission requirements.

In the area of design methods, emphases will be on improved computational efficiency and continued development of structural modeling and analysis methods to meet the design needs of future space systems, including nonlinear behavior due to large deformations and nonisotropic composite material application, fatigue life of advanced metallic and composite materials, and structural/controls dynamic interactions.

In dynamics, the focus will include the adaptation of payload loads and vibroacoustic design methods to shuttle-type vehicles and the development of concepts for control of structural dynamic modes of space systems and improved methods of dynamic model testing.

The high-temperature structures effort will continue development of metallic structures for Earth entry vehicles capable of withstanding temperatures of 1500°F or more, metallic multiwall thermal protection systems, and validated thermal stress prediction methods.

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	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Sensing and Detection Research and Technology.....	4,400	4,950	4,895	5,400

OBJECTIVES AND STATUS:

The objectives of the Sensing and Detection Research and Technology program are to provide advanced concepts, technologies and components to improve the data acquisition capabilities of future applications and science missions and to ensure their long-term reliability.

The attainment and testing of ultrasensitive silicon charge-coupled device arrays with up to 640,000 sensing elements has resulted in their acceptance for the cameras to be used on the Space Telescope and Galileo missions.

The first linear array with infrared capability out to 5 micrometers has been developed and tested. In addition, millimeter and submillimeter wave solid-state components have been developed for radiometric measurements related to severe storm predictions and pollution detection.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease of $55 thousand is a result of rebalancing funding between the Sensing and Detection and the Guidance and Control Research and Technology Base efforts.

BASIS OF FY 1980 ESTIMATE:

New technologies are being investigated to improve the observational capabilities of sensing systems. In FY 1980, the spectral range of terrestrial images will be extended to the middle infrared region in order to map the thermal variations of the Earth's surface. For the far infrared region, charge-coupled devices will be developed and evaluated for measuring remote star fields. Near infrared devices will be developed for observing planetary and terrestrial surface geochemical characteristics.

Lasers and electro-optical systems are being developed for acquiring specific data related to terrestrial and atmospheric properties. In FY 1980, the reliability of solid-state tunable laser diodes will be emphasized to assure their long-life performance for long-duration space missions. For measuring geodetic changes due to small crustal motions of the Earth, a high-pulse rate, high-energy-per-pulse lasing system will be developed to accomplish highly accurate ranging from a low orbit space platform to passive ground-based retroreflector targets.

Microwave components, technologies, and systems are being developed to achieve a near all-weather 24-hours-a-day sensing capability from potential future space platforms. In FY 1980, linear arrays of small radiometers will be developed to achieve spatial resolutions as low as 1 kilometer. Submillimeter wave components will be developed for frequencies as high as 1 terahertz in order to monitor stratospheric constituents that are involved in the ozone chemistry cycle. Millimeter wave components will be developed for measuring the Earth's environmental parameters such as water vapor, temperature, precipitation and wind speed.

To ensure the reliable operation of sensor components and related electronic systems, failure mechanisms are being investigated in order to determine the causes of breakdowns and to formulate guidelines for minimizing failures. In FY 1980, emphasis will be placed on chemical and electrical evaluations of charge-coupled device structures, and semiconductor structures.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Guidance and Control Research and Technology.....	3,500	3,850	4,000	4,300

OBJECTIVES AND STATUS:

The objective of this program is to develop components and techniques which will lower the costs and improve the performance of spacecraft attitude control systems, provide precise pointing of experiments, improve the accuracy of space navigation, and permit autonomous operation of spacecraft, robot vehicles operations and experiments in space, and supporting ground activities.

The fabrication of the engineering model hardware for the Annular Suspension and Pointing Systems design was completed and assembly and test begun; the Feature Identification and Location Experiment capability was verified by ground field tests, and the experiment will be conducted on a Shuttle orbital flight test; the Extended Life Attitude Control System effort was completed, and laboratory tests demonstrated that use of a solid-state star tracker yielded a factor of four improvement in accuracy over the current star tracker; and an advanced Fiber Optics Rotation Sensor was constructed and tested, further verifying the potential of this approach. In the automated operations area, the Optical Navigation experiments, using Viking, were completed; an Automated Optical Navigation configuration design was selected for development; and work was initiated in automatic image classification using Viking images.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The increase of $150 thousand reflects relatively unanticipated increases contractor and in-house costs, as well as the balancing of funding among the other disciplines within the Research and Technology Base.

BASIS OF FY 1980 ESTIMATE:

Precision pointing and control research emphasizes new concepts and components which promise reduced costs and increased mission capability. In FY 1980, development of concepts and technologies needed for control of flexible space structures will be emphasized. Development will continue on the design of an engineering model of a fiber optics rotation sensor with no moving parts that promises to provide long life, high sensitivity and low cost. Fabrication and test of precision experiment pointing and tracking system design for planetary applications will be completed. Techniques will be developed for noncontacted signal and power transfer for advanced experiment pointing systems to realize their full potential.

On-board navigation techniques are being developed to reduce costs and increase the scientific return for both Earth orbital and planetary missions. In FY 1980, an automated navigation system relying on on-board optical measurements will be implemented using a ground computer, and the system will be readied for flight use. An advanced configuration of the Feature Identification and Location Experiment will be completed, and the video landmark tracker approach to the next step will be defined.

During FY 1980, work will be expanded in developing techniques for applying machine intelligence t space program to increase productivity and reduce costs. Laboratory demonstrations will be conduct automated manipulator technology for assembling space structures. Techniques for semiautonomous mi operations using "high level" ground commands, instead of detailed step-by-step program instructions spacecraft, will be demonstrated in the laboratory. Using an advanced automated problem-solver, a learning and error-correcting system will be developed and demonstrated. University studies on developing new robotic and machine intelligence techniques will be continued.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Data Reduction and Distribution Research and Technology	6,500	8,300	8,300	9,700

OBJECTIVES AND STATUS:

The objective of the Data Reduction and Distribution Research and Technology program is to provide advanced concepts, components and techniques which will improve the efficiency and reduce the cost of data handling and information extraction processes for experimental and operational space missions of the future.

During FY 1979, definition of improved data handling system concepts will be completed, a distributed data system architecture will be breadboarded, and development of improved support tools for flight software generation will be initiated. Development of a ground-based synthetic aperture radar data processor will continue, and an engineering model multispectral data processor will be assembled. A three-channel data editor using integrated optics will be assembled and tested.

In addition, an X-band solid-state transmitter will be field tested. Developmental low-noise receivers and phased-array antennas for Ku-band operation will be acquired and evaluated. Design specifications for an X-band transponder will be completed and a high data-rate fiber-optic link will be acquired for test and evaluation.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, a simulated end-to-end data system will be established and parametric studies will be conducted to optimize data handling efficiency and cost. Large scale integrated circuit components for a distributed architecture data system will be assembled and tested. Development of software support tools will continue, with emphasis on microprocessor software requirements.

A developmental synthetic aperature radar processor will be assembled and evaluated. Performance of the engineering model multispectral data processor will be tested and required design improvements initiated. High-density interconnection techniques to provide three-dimensional packaging of large scale integrated circuits will be investigated.

An advanced data processor concept combining surface acoustic wave and charge-coupled device technologies will be breadboarded, and high-density "bubble domain" memory devices employing "lattice-file" structures will be fabricated and evaluated.

Cold cathodes to improve the operating life of high-power traveling wave tubes will be evaluated. Work on solid-state 20 Gregahertz (GH_z) power amplifiers and 30 GH_z low-noise receivers will be initiated. Fabrication of an engineering model X-band transponder will begin and testing of a one gigabit/second fiber optic data link will be completed.

Development of custom large scale integrated circuit technology will continue with emphasis on computer aided techniques for design, fabrication and test.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Chemical Propulsion Research and Technology.....	8,100	9,200	9,200	9,900

OBJECTIVES AND STATUS:

The objective of this program is to advance the technology of high-thrust chemical propulsion systems in order to achieve significant reduction in the development, production and operations costs and to improve the performance capability of future space transportation vehicles and long-life spacecraft systems.

Significant progress has been made during the past year, both in advanced space transportation system propulsion and in long-life spacecraft systems. High-pressure pumps for oxygen-hydrogen engines applicable to orbital transfer vehicles have demonstrated design performance. Carbon/composite thrust chambers for a fluorine-hydrazine planetary obriter propulsion system have demonstrated successful operations at 3000 to 4000°F.

BASIS OF FY 1980 ESTIMATE:

Advanced high-performance reusable chemical propulsion efforts will provide the technology for future space transportation systems, including small orbital transfer vehicles and advanced Earth-to-orbit vehicles. Technology for small oxygen-hydrogen systems demonstrating long service life is being completed. In FY 1980, the technology for small oxygen-hydrogen engines will be directed toward evaluating engine concepts designed for very low thrust operations. Systems to be considered will include single engines, designed for both high thrust and low thrust, and engines designed for low-thrust operation only. Research and technology on high-density fuel engines for advanced Earth-to-orbit vehicles will continue in the areas of simplified servicing techniques and component designs for long service life, combustion, heat transfer and cooling, and expansion nozzle configurations designed to maximize specific impulse over a variety of engine operating conditions and altitudes.

Long-life spacecraft propulsion technology activities are directed toward systems designed to operate reliably over long periods of time, up to 10 years in space, without benefit of repair or refurbishment. These research and technology efforts include planetary retro-propulsion, deorbit, atmospheric entry, landing, and launch propulsion systems, as well as spacecraft auxiliary propulsion. Components developed will be available for assembly into a complete space-storable fluorine-hydrazine planetary retro-propulsion system under the Propulsion and Power Systems Technology program. Work will also continue in the technology areas of high-performance, heat-sterilizable solid propellants for planetary deorbit and surface-to-orbit launch systems.

RD 10-10

Basic research will be continued to expand understanding of the chemical and physical processes that occur in rocket propulsion systems. The search for advanced concepts that will provide a new level of capability beyond conventional chemical propulsion systems will also continue. In FY 1980, the efforts will include continuation of combustion studies, exhaust plume definition and analysis of effects, performance prediction techniques, solid propellant polymers and viscoelastic properties, behavior of fluids in a low-gravity environment, and laser propulsion feasibility studies.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Electric Propulsion Research and Technology.....	6,300	7,000	7,000	7,500

OBJECTIVE AND STATUS:

The objective of this program is to provide the research and technology for the low-thrust, high-specific-impulse electric propulsion systems needed for advanced capabilities in near-Earth and planetary missions.

Design and fabrication efforts for a building-block primary propulsion thrust model are on schedule. In addition, work continues on auxiliary thruster flight test hardware.

BASIS OF FY 1980 ESTIMATE:

In the auxiliary electric propulsion area, an endurance test of a one-millipound thrust system will continue during FY 1980. The technology effort in support of an ion thruster flight test on a Shuttle-launched Air Force space test program satellite will be completed. A preliminary study of the propulsion requirements for future space systems will also be completed.

Resources in the primary electric propulsion program are directed toward completing the Solar Electric Propulsion technology readiness effort in FY 1980. The activity includes a multiple thruster mission profile life test and an endurance test of an engineering model thrust module. During FY 1980, work will also be continued on the development of technology for extending thruster performance over a broader range of specific impulse, thrust, and power.

Basic technology efforts will continue to support the auxiliary and primary electric propulsion efforts by providing a better understanding of the physical processes that limit life and efficiency. In FY 1980, studies will continue to evaluate critical technologies of advanced propulsion concepts such as the mass driver and the magnetoplasmadynamic accelerator. In addition applications of ion beam technology to other than propulsion uses will continue to be explored.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Space Energy Systems Research and Technology.....	9,600	11,200	11,200	11,900

OBJECTIVES AND STATUS:

The objective of this program is to provide the technology basis for future space power systems needed for use in-near-Earth space and in the exploration of the solar system.

A major accomplishment that occurred during this past year was the successful ground extension and retraction tests of a 12.5 kilowatt, 66 watts per kilogram solar electric power array. This array is being evaluated as the technology basis for a number of anticipated future mission needs such as Shuttle power augmentation and electrically propelled spacecraft. In other areas, advances were made toward solar cells with increased efficiency and tolerance to the radiation environment, as well as establishing the manufacturing feasibility of cells with three times the power output per unit mass of current flight technology cells. Fuel cell elements capable of sharing reactants and tankage with rocket engines were demonstrated. In addition, a new transistor capable of handling power levels six times greater than previously possible was demonstrated.

BASIS OF 1980 ESTIMATE:

Photovoltaic research and technology will continue to seek advances in solar cells; the covering, interconnecting, and supporting these cells into modules; and arrays. In the cell area, focus will be on incorporating a variety of advances in efficiency, radiation immunity, and structure into the thin (approximately fifty microns) silicon solar cell. Work on alternative materials to silicon will also be pursued, as will advances in understanding the radiation damage repair prospects of thermal annealing. In the module area, research on encapsulants, adhesives, substrates, and welding will continue, with emphasis on thin cell cover systems. In the array area, both lightweight and low-cost techniques will continue to be explored.

Research aimed at doubling the life of the high energy density Nickel-Cadmium battery by 1981 will continue. Work recently initiated to produce high-capacity energy storage required for future high power missions will

continue. Emphasis will be placed on the fuel cell electrolyzer and high-capacity battery cells. In addition, work toward very high energy density storage systems, based on sodium and lithium, will continue.

In the thermal conversion area, work toward promising high-efficiency (15 percent) thermionic and thermoelectric converters will emphasize fabrication of a half length heat pipe/thermionic converter system. Life testing of the 10-kilowatt Brayton cycle rotating unit is also expected to be completed in FY 1980.

As a result of cooperative efforts with the Air Force, design criteria for protecting systems from the effects of spacecraft charging at high orbital altitudes will be established. In addition, analytical and experimental assessments of the interaction between high voltage surfaces and the surrounding space plasma will continue.

In the area of power management and distribution, work will continue on high-power switchgear, high-frequency (50 kilohertz) converters, and automated power management. Initial evaluation of automated management of planetary solar array/battery systems will be completed in FY 1980.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Nuclear energy Research and Technology.....	1,200	---	---	---

OBJECTIVES AND STATUS:

The Nuclear Energy Research and Technology program was concluded in FY 1978. In prior fiscal years, gaseous fuel reactors have been the subject of research and engineering investigations into the feasibility of advanced concepts for space nuclear power and propulsion. The major focus of this research has been a series of proof-of-principle experiments conducted for NASA by the Los Alamos Scientific Laboratory. The funding provided in FY 1978 carried this series to a logical conclusion through the accomplishment of goals established at the start of the program. With the success of these tests, this research effort on gaseous fuel reactors has proven the essential capability of the concept to produce power in a configuration that could be scaled to high performance levels.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
High Power Lasers and Energetic Research and Technology	6,500	6,700	6,700	6,800

OBJECTIVES AND STATUS:

The High Power Lasers and Energetics Research and Technology program provides, through basic research and experimental engineering, major technology advances in the generation, conversion, and transmission of energy for future capabilities in space. It also supports research on cryogenic systems required to operate sensors and other equipment in space.

Recent progress includes the demonstration of phase-locking of high-power lasers. This achievement has significance in the scaling of laser systems to extremely high power levels and represents the first-reported observation of a conducting (metallic) state in xenon. In addition, precisely-tuned short-wavelength laser, suitable as a remote-sensing instrument which can be carried in balloons, aircraft or spacecraft has been developed. The operation of a cryogenic cooler unit, based on helium-3 and capable of use in the zero-gravity environment of space flight has also been accomplished.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, magnetics and cryophysics research will concentrate on means to extend the operating durations of coolers for space missions involving both mechanical devices and superfluid helium. Emphasis will also be placed on atomic and metallic hydrogen as potentially new concepts for energy storage.

In fundamental photonics, basic research will focus on the emission and absorption of radiation from all states of matter in support of power generation, propulsion, laser, space environment, and atmospheric physics. Areas of continuing emphasis are the direct conversion of fission fragment energy into coherent light, the coupling of electron beams with laser beams, and the chemistry and physics of high-power laser beams in remote sensing of terrestrial and planetary atmospheres and surfaces. In addition, experimental studies of advanced solar energy conversion will continue.

FY 1980 high-power laser systems research will continue investigations of the conversion of laser energy to electrical energy or directly to propulsive forces.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Entry Research and Technology.....	6,305	5,800	5,800	6,100

OBJECTIVES AND STATUS:

The objective of this program is to improve the understanding of the aerothermodynamic, gasdynamic and flight mechanic problems of spacecraft designed for Earth orbital missions and planetary exploration. This knowledge will be used to improve the safety, reliability and efficiency of these spacecraft.

In the area of Shuttle aerothermodynamics, and analysis of all available aerodynamics data obtained on the Orbiter was completed and the subsonic, transonic, supersonic, and hypersonic/viscous sections of the Orbiter Aerodynamic Design Data Book was updated. In addition, technology assessment studies completed in the past year have indicated that for advanced heavy-lift single-stage-to-orbit vehicles, the far aft center of gravity location (75 percent of length) is a major design issue that must be addressed and solved before the advantages associated with advanced technology can be realized. In the area of planetary entry probes, the capability has been developed to calculate the turbulent flow field about a massively ablating sphere cone entry body during descent through the atmosphere of Jupiter. In the flight data analysis effort, several experiments to be conducted on the Shuttle Orbiter are under construction. These experiments will provide research-quality data for use in evaluating theoretical and experimental methods.

BASIS OF FY 1980 ESTIMATE:

In the area of advanced Earth-orbital transportation aerothermodynamics, the objective is the development of a fundamental understanding of the phenomena involved and approaches to future vehicle designs. These efforts are aimed at improving performance and reliability and reducing costs for a variety of potential space missions. In FY 1980, continued emphasis will be placed on development of theory, advanced computational methods, and computer codes for predicting vehicle flow fields and performance; development of improved ground-based experimental techniques, instrumentation and simulation capability; advanced vehicle design integration capability; and the development of an aerothermodynamic data base from ground facility and flight investigation to support future advanced vehicles.

The planetary probe technology effort provides the aerothermodynamic base which supports current and future scientific missions to study the atmospheres of Venus, Mars, the outer planets and certain of their satellites. This technology base supports the aerothermodynamic design, development, and verification of planetary probe

configurations and provides the flight mechanics data in support of the atmospheric reconstruction experiments. In FY 1980, theoretical and experimental efforts will be continued in the areas of shock-layer radiation, ablation product radiation and absorption, highly blown shock-layer, probe flight mechanics, and mass loss and shape change. These studies will be pursued to develop a data base to minimize planetary mission costs, to maximize the scientific returns, and to insure a high probability of mission success.

The space shuttle aerothermodynamic effort in FY 1980 will provide support in the form of ground-based facility analysis of test results.

The aerothermodynamic flight data analysis effort will use the Orbiter Experiment flight data to understand phenomena which cannot be simulated in ground facilities, to develop techniques for extrapolating ground facility results to flight conditions, and to verify analytical and computational prediction techniques. In FY 1980, analysis techniques and associated software will be developed and the data base will be defined in preparation for analysis of flight data.

SYSTEMS STUDIES

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Systems Studies.....	2,000	2,000	2,000	2,200

OBJECTIVES AND STATUS:

The objectives of System Studies are to identify and evaluate the technology requirements of advanced system candidates; to investigate future space mission alternatives; to assess the effects of technology advances; and to provide a data base to support technology program selection and program planning. Studies will continue to examine: the development of future program technology needs; subsequent determination of detailed technology requirements and alternative solutions for satisfying needs and requirements.

During FY 1979, studies have been extended to develop technology requirements for a space-based radio astronomy antenna; a space-based mission for detecting planetary systems beyond our solar system; and the readiness of radar technology for the Venus Orbiting Imaging Radar and potential ocean condition monitoring missions. Studies are continuing to investigate the possible utilization of nonterrestrial resources for space applications. Studies of future concepts for global service platforms to meet the total information collection and transfer needs of the 1990's are being continued. Platform studies have been initiated and low-thrust orbital transfer technology options are being developed. Technology requirements for multipurpose platforms, including structures, antenna and power, are being evaluated.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 efforts will continue to focus on the themes of technology for future space applications, explorations and transportation.

A continuing study emphasis will be placed on technology for Earth applications. This multi-Center activity, which developed baseline configurations for the advanced global services concept, will continue to conduct parametric trade studies of system options. Space applications theme studies dealing with advanced concepts and technologies will be continued and/or initiated.

Exploration technologies study programs will examine integrated Earth orbiting platform systems for scientific missions. Critical technology issues associated with planetary sample return missions will be examined.

Transportation studies will continue to focus on orbital transfer technology issues and to formulate specific recommendations for technology programs to respond to total space transportation system needs and opportunities.

Utilization of space studies will be directed at defining experimentation in ground- and space-based facilities to gain a better understanding of the nonterrestrial materials options.

Advanced concept development studies will continue to serve as a basis for modeling future technology needs and requirements.

Technology-specific studies will catalogue and rank available, planned and forecasted technology from sources within and outside NASA. Continuing studies of technology seek to rank options and to develop strategies for the the attainment of long-range goals through application to near-term missions. Special study emphasis will be given to key technology issues, such as automation, space structures and materials, cryogenic systems, reusable propulsion, end-to-end data management and kilowatt/megawatt power sources for the purpose of defining future program options.

BASIS OF FUND REQUIREMENTS:

SYSTEMS TECHNOLOGY PROGRAMS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Electronic systems technology	1,000	3,200	3,200	9,900	RD 10-18
Materials and structures systems technology	4,000	3,800	3,800	5,200	RD 10-19
Propulsion and power systems technology	800	900	900	900	RD 10-20
Total	5,800	7,900	7,900	16,000	
Electronic systems technology	1,000	3,200	3,200	9,900	

OBJECTIVES AND STATUS:

The objective of this program is to integrate advanced electronic devices or system concepts developed in the Research and Technology Base with supporting technology to demonstrate and validate improved performance, increased reliability and reduced costs of space electronics and data handling systems.

In FY 1979, the second phase of the NASA End-to-End Data Systems (NEEDS) program was initiated. The first phase, which was carried out in the Research and Technology Base program, focused on the development of critical component technologies and system concepts to meet the high data-rate processing demands of future space missions. The second phase is to develop and evaluate engineering subsystem and system hardware required to provide near real-time processing of space-derived data and demonstrate increased data-handling capability at reduced costs. During FY 1979, system parameters will be established; design specifications for major hardware subsystems will be developed; and external and internal system interfaces will be defined. Major subsystems include an Information-Adaptive Data System, Modular Data Transport System, Massively Parallel Processor, Archival Mass Memory and a Data Base Management System.

BASIS OF FY 1980 ESTIMATES:

The principal activity in the second phase of the NEEDS program during FY 1980 will be the development of system and subsystem hardware. Major subsystems will be procured through contractual efforts with industry. This activity will extend into the FY 1981 timeframe and will be supplemented by in-house activities to develop necessary software and system interfaces. Subsequent efforts will integrate the major elements into a systems breadboard that will be tested and validated in representative data management applications.

A key activity in FY 1980 will be the initiation of systems technology efforts for advanced space communications--satellite communications technology. This activity is to develop and evaluate specific hardware components required to support advanced communication systems developments in Space Applications. These complementary activities are an important step toward maintaining the Nation's leadership in space-base communications technology. FY 1980 efforts will focus on the development of multi-beam antenna feeds and switches, efficient power amplifiers, low-noise mixers, and on-board processors for signal routing and storage. Breadboard hardware configurations will be built and tested. In addition, performance characteristics will be assessed and design specifications for system applications will be prepared. Propagation modeling and ground terminal technology development will be added to complete and integrated technology program.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Materials and structures systems technology.....	4,000	3,800	3,800	5,200

OBJECTIVES AND STATUS:

The objectives of this program are to expand the materials and structures technologies developed in the Research and Technology Base program and to verify their validity by extensive test of large scale systems to facilitate timely use in space systems design.

In the Composites for Advanced Space Transportation Systems (CASTS) program, four polyimide matrix systems has been selected, and fabrication technology developments are under contract for these materials. Two high-temperature adhesives have been identified for this 600°Fahrenheit application. In the Space Structures Systems Technology efforts, future space systems have been defined; critical technology requirements have been identified; and concepts for deployable and erectable reflectors and platforms are being developed.

BASIS OF FY 1980 ESTIMATE:

During FY 1980, emphasis will be given to the fundamentals associated with graphite/polyimide panels to determine strength and life at 600° Fahrenheit.

The objective of the space structures systems technology activity is to provide the enabling technology in structures, materials, assembly, and controls to support future design of space systems. In FY 1980, technology verification of structural elements, components, and assembly methods for platforms and reflectors will be continued. Requirements for control of space structures will be defined, and development of control systems technology will be initiated.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Propulsion and power systems technology.....	800	900	900	900

OBJECTIVES AND STATUS:

The objective of this program is to demonstrate technology readiness of advanced space propulsion and power systems by conducting tests of complete systems assembled from advanced technology components already demonstrated under the Research and Technology Base. The system/level tests are designed to evaluate component interactions and to demonstrate overall system performance and operation, under both transient and steady-state operating conditions.

The program to advance the technology of high-energy, space-storable propulsion systems has encountered some minor problems in engine cooling. Some component procurements have been delayed in order to focus attention on the cooling problems.

BASIS OF FY 1980 ESTIMATE:

The goal of the Long Life Chemical Propulsion Systems activity is to design, fabricate, assemble, and test a near flight-weight advanced planetary orbiter spacecraft propulsion system, utilizing high-performance space-storable fluorine-hydrazine propellants under simulated space vacuum conditions. The objective is to demonstrate overall propulsion system performance and operation, and establish handling, safety and launch operation procedures. In FY 1980, all component and subsystem design verification testing efforts will be completed and final component procurements initiated, including the flight-weight fluorine-hydrazine thrust chamber assembly.

BASIS OF FUND REQUIREMENTS:

EXPERIMENTAL PROGRAMS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Space technology Shuttle/Spacelab payloads.....	15,395	17,700	16,605	18,100
Space transportation system operations.....	(---)	(2,600)	(2,600)	(4,800)

OBJECTIVES AND STATUS:

The objective of this program is to provide the capability to extend research and technology programs into space when that unique environment is essential to the progress of a program, when an in-space test is cost effective, when an in-space verification will accelerate the utilization of advanced technology, or when there exists the opportunity to exploit the operation of a space system for research. The program provides for the definition, development, and management of experiments, payloads and facilities which capitalize on the capabilities of the Space Shuttle, the Spacelab, and free-flying spacecraft.

In FY 1979 the ion engine experiment, the only effort in the Free-Flying Payload activity, will be delivered to the United States Air Force for integration with its Teal Ruby Satellite.

The integration of experiments to be conducted on Shuttle/Spacelab missions has been delayed consistent with the changes in the schedule. The experiment hardware development schedules are being maintained to avoid stretchout-driven overruns.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease of $1,095 thousand reflects the Space Research and Technology portion of the Congressional general reduction in NASA's Research and Development appropriations request.

BASIS OF FY 1980 ESTIMATE:

In FY 1980, the Long Duration Exposure Facility (LDEF) and the 35 experiments involving 70 investigators will be integrated. These experiments were selected from proposals submitted in response to the first LDEF Announcement of Opportunity.

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In FY 1980, experiments will be conducted during the Shuttle orbital flight test missions. The Spacelab 1 and 2 experiments will be delivered to the integration site. The Solar Electric Propulsion solar array demonstration hardware will complete pre-flight tests and will be delivered for integration with the assigned pallet. Experiments for subsequent Spacelab missions are being phased to assure their continued compatibility with the Space Research and Technology Base efforts. In FY 1980, development of critical high priority experiments such as cryogenic management, propulsion contamination effects, and solar cell performance verification will be continued to assure their timely application to future program requirements.

The Orbiter Experiments activity will include the core experiments, using the Shuttle capabilities as an advanced research vehicle to conduct aerothermodynamics investigations. The windward temperature experiment, utilizing the NASA C-141 telescope facility, will be used during selected OFT returns. The Aerodynamic Coefficient Identification Package will be flown during the orbital flight test missions to collect data. Two thermal protection tile experiments will be completed, tested and delivered to the Kennedy Space Center. In addition, the hardware for the leeside heating experiment and the improved air data system packages will be completed.

BASIS OF FY 1980 FUNDING REQUIREMENTS:

STANDARDS AND PRACTICES

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Standards and practices	9,000	9,000	9,000	3,000

OBJECTIVES AND STATUS:

The Standards and Practices Program provides for approaches to minimize the costs of NASA projects by encouraging the use of space-qualified equipment on multiple missions, product improvement through component upgrading, and on improvement of program practices, concentrating on such areas as specification, testing and flight project analysis.

These objectives are being accomplished in two functional areas: standard equipment and program practices. Within the standard equipment area, standards fall into six disciplines: (1) electrical power; (2) communications and data handling; (3) auxiliary propulsion; (4) stabilization, guidance and control; (5) ground support

equipment; and (6) payload instrumentation. Those items which could meet the requirements of multiple users are identified by agency-wide panels, which define the requirements and interfaces of suitable hardware.

Program practices activities involve the review and evaluation of techniques associated with the major cost elements of hardware acquisition, development, integration, and project operations. In addition, efforts are underway to establish a readily accessible computer listing of available space-qualified hardware.

Through FY 1979, approximately thirty components will have been declared as standard items for use on NASA missions. These standards include items such as tape recorders, flight computers, transponders, igniters, batteries, power regulators, thrusters, test sets, star trackers, reaction wheels, inertial reference units, data handling and command components, cameras, and articulation systems. Fourteen of these standards have completed development and qualification and are now available for flight project use. During the past year, the practices activity reviewed major NASA flight projects to determine the practices used, continued development of engineering standards for STS payloads, and participated in the development of an automated procurement system.

With the completion of a significant number of standardization efforts, the Standards and Practices program in FY 1980 will be redirected to focus more on maintenance and product improvement of existing standards, while placing emphasis on program practices.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 budget request places emphasis on product improvement of developed standard hardware, including the upgrading and technological enhancement of selected components. Development efforts will be completed on nine additional components. Increased emphasis will be placed on program practices, with major thrusts in the areas of specifications, test, and flight project analysis.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

ENERGY TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Energy technology	7,500	3,000	5,000	3,000
Distribution of Program Amount by Installation:				
Johnson Space Center	875	---	900	---
Marshall Space Flight Center	1,165	---	1,500	850
Jet Propulsion Laboratory	1,551	1,400	1,200	1,050
Ames Research Center	140	---	---	---
Lewis Research Center	1,409	1,600	1,400	1,100
Headquarters	2,360	---	---	---
Total	7,500	3,000	5,000	3,000

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY — ENERGY TECHNOLOGY

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of this program is to relate NASA's aeronautical and space technologies, engineering, scientific, and managerial expertise, and existing facilities capabilities to the research and development needs of the Department of Energy and other agencies. These activities contribute to the search for solutions to energy problems on Earth. The Energy Technology activity accomplishes the program objective through investigations of the potential application of NASA capabilities to energy-related problems and development of plans for reimbursable support for work which NASA could appropriately perform when the investigations are sufficiently mature. These investigations form a basis for Department of Energy decisions concerning programs in critical energy R&D areas.

The success of this approach is borne out by the fact that in FY 1979 NASA's energy-related reimbursable efforts for the Department of Energy will total approximately $160 million. The Department of Energy has assigned to NASA expanded project responsibilities in such areas as Wind Energy, Low-Cost Solar Cell Arrays, Solar Heating and Cooling, Energy Storage, Solar Thermal Electric Conversion and Automotive Heat Engine Technology. In addition, reimbursable support will be initiated in FY 1979 in the Satellite Power System and Nuclear Waste Management in Space study areas.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

Final Congressional action on the FY 1979 R&D budget request added $2 million for satellite power system technology work. These funds are to be used for critical technology investigations in the areas of microwave power transmission, energy conversion, power distribution and processing, and materials and controls.

BASIS OF FY 1980 ESTIMATE:

During FY 1980, NASA's energy technology efforts will continue to focus on areas where NASA-developed expertise can be utilized. This will include investigations in: Stirling Engines, Gas Turbine Materials and Combustion Techniques, Coal Cleaning and Conversion, Cogeneration, Industrial Process Energy Conservation, and Integrated Solar Power Systems Applications.

In addition to bringing new capabilities to bear on energy problems, this work will capitalize on the experience which NASA has gained in support of the DOE in prior years.

Beginning in FY 1979, the Department of Energy budgeted for the joint DOE/NASA satellite power system studies. The funding for continuation of these joint studies in FY 1980 and subsequent years is to be included in the DOE budget request.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1980 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRACKING AND DATA SYSTEMS

TRACKING AND DATA ACQUISITION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate	Page No.
		(Thousands of Dollars)			
Operations	228,584	254,200	251,600	275,800	12-4
Systems implementation	40,400	41,300	40,500	46,400	12-15
Advanced systems	9,316	9,900	9,900	10,600	12-23
Total	278,300	305,400	302,000	332,800	
Distribution of Program Amounts by Installation:					
Goddard Space Flight Center	199,211	220,700	216,200	238,200	
Jet Propulsion Laboratory	57,626	63,600	61,300	68,800	
Wallops Flight Center	5,444	5,600	5,900	6,300	
Dryden Flight Research Center	3,154	3,500	3,300	3,000	
Headquarters	12,865	12,000	15,300	16,500	
Total	278,300	305,400	302,000	332,800	

OFFICE OF SPACE TRACKING AND DATA SYSTEMS

TRACKING AND DATA AQUISITION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

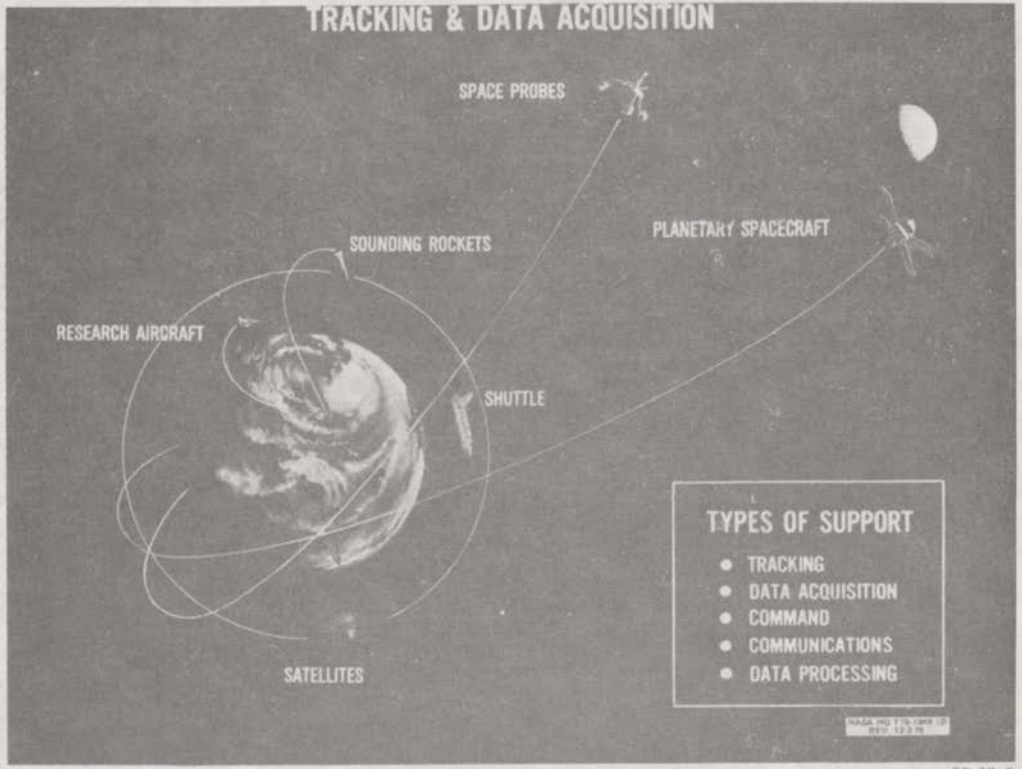
The purpose of this program is to provide vital tracking and data acquisition support to meet the requirements of all NASA flight projects. In addition to NASA flight projects, support is provided, as mutually agreed, for projects of the Department of Defense, other Government agencies, commercial firms, and other countries and international organizations engaged in space research endeavors.

Support is provided for: sounding rockets, research aircraft, earth orbital and suborbital missions, for lunar and planetary spacecraft, and for deep space probes as depicted in Figure 1. It also includes the support of all phases of the Space Shuttle program, from the completed Approach and Landing Tests to the upcoming Orbital Flight Tests, and the Space Transportation System operational flights.

The various types of support provided include: (a) tracking to determine the position and trajectory of vehicles in space; (b) acquisition of scientific and earth applications data from onboard experiments and sensors; (c) acquisition of engineering data on the performance of spacecraft and launch vehicle systems; (d) transmission of commands from ground stations to spacecraft; (e) communication with astronaut- acquisition of biomedical data on their physical condition; (f) communication of information bet various ground facilities and central control centers; and (g) processing of data acquired from vehicles and spacecraft. Such support is essential for achieving the scientific objectives of a: missions, for executing the critical decisions which must be made to assure the success of these i... missions, and, in the case of Shuttle missions, to insure the safety of the crew.

Tracking and acquisition of data from the space flight projects is accomplished by the use of a world-wide network of NASA ground stations. These facilities are interconnected by ground communications lines, undersea cables, and communications satellite circuits which are leased from communications carriers, both domestic and foreign. This interconnection provides the communications capability needed between spacecraft in space and control centers in the United States from which the flights are directed.

To meet the support requirements levied by the wide variety and large number of flight projects, NASA has established two types of facilities to meet the needs of the two basic classes of NASA flight missions. These are the Spaceflight Tracking and Data Network (STDN), which supports earth orbital scientific and applications programs, and the Deep Space Network (DSN), which supports planetary and interplanetary flight missions.


TRACKING & DATA ACQUISITION
SPACE PROBES
PLANETARY SPACECRAFT
SOUNDING ROCKETS
RESEARCH AIRCRAFT
SHUTTLE
SATELLITES
TYPES OF SUPPORT
TRACKING
DATA ACQUISITION
COMMAND
COMMUNICATIONS
DATA PROCESSING

RD 12-3

Computation facilities also are provided to process into meaningful form the large amounts of scientific, applications and engineering data which are collected from flight projects. In addition, instrumentation facilities are provided for support of sounding rocket launchings and flight testing of aeronautical research aircraft.

The Research and Development appropriation provides funds for: (a) the operation and maintenance of the worldwide facilities; (b) the engineering and procurement of equipment to sustain and modify the network systems to support continuing, new and changing flight project requirements; and (c) the development of advanced tracking and data acquisition systems and the investigation of advanced tracking and data acquisition techniques.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The current estimate for FY 1979 is $3.4 million below the budget estimate. Of this amount, $2.4 million reflects the impact of Congressional reduction in the Tracking and Data Acquisition budget request for FY 1979. Of the $2.4 million reduction, $1.4 million was identified with support of the search for extraterrestrial intelligence (SETI) research and $1.0 million was unspecified. An additional $1.0 million reduction in the Tracking and Data Acquisition budget request for FY 1979 resulted from a $4.5 million unspecified Congressional reduction in the FY 1979 NASA Research and Development appropriations request. The allocation of the unspecified reduction is consistent with the Shuttle schedule and the early deactivation of the tracking ship, the USNS Vanguard.

BASIS OF FUND REQUIREMENTS:

OPERATIONS

The FY 1980 funding requirements are based upon a continuing support workload for an average of approximately 60 automated earth-orbiting and planetary missions. The operations funding will also provide for the pre-launch support activity required for upcoming approved missions. The increase in the FY 1980 funding request for Operations is due to two factors: (1) continuing cost escalation in all areas of Operations; and (2) support of the upcoming Shuttle Orbital Flight Tests requiring additional activity in the Spaceflight Tracking and Data Network and a significant increase in the costs or the additional wideband communications circuits to transmit the high volume of data between the Shuttle and the ground control facilities.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	Budget Estimate	Page No.
		(Thousands of Dollars)			
Spaceflight tracking and data network	120,170	129,900	129,100	141,200	12-5
Deep space network	46,570	49,800	49,800	55,600	12-7
Aeronautics and sounding rocket support	4,982	4,900	4,900	4,800	12-10
Communications	27,931	37,900	34,800	39,800	12-11
Data processing	28,931	31,700	33,000	34,400	12-13
Total	228,584	254,200	251,600	275,800	
Spaceflight Tracking and Data Network Operations	120,170	129,900	129,100	141,200	

OBJECTIVES AND STATUS:

The primary function of the Spaceflight Tracking and Data Network is to support all NASA earth orbital space flight missions, including the Space Shuttle. The majority of these missions have near-earth orbits; however, the network also supports selected missions through lunar distances and beyond, such as the International Sun-Earth Explorer missions. In addition, the network provides launch support to NASA's automated planetary missions, as well as the spaceflight missions of other nations, commercial firms, the Department of Defense, and other United States Government agencies. Accordingly, the network must be responsive to the requirements of a large number and wide variety of flight projects from launch through completion of the flight project objectives. In many instances, the period of network support required by the flight projects continues for several years.

The Spaceflight Tracking and Data Network presently consists of fourteen geographically dispersed ground stations, thirteen of which are located at remote sites and one at the Goddard Space Flight Center (GSFC), Greenbelt, Maryland. A network control center and mission control center complex are also located at the GSFC which has the field center management responsibility for the network.

These global facilities have the capability to electronically track the spacecraft, send commands for spacecraft and experiment control purposes, receive engineering and scientific data from the spacecraft, and in the case of the astronauts, maintain voice communications for crew safety and other project related purposes. To meet the extremely precise tracking needs of NASA's Earth and Ocean Dynamics Programs, the network is supplemented by laser tracking systems capable of providing precise tracking accuracies.

In addition to the operational facility at Goddard, the thirteen land stations are located at Fairbanks, Alaska; Goldstone, California; Merritt Island, Florida; Kauai, Hawaii; Rosman, North Carolina; Guam; Ascension Island; Canberra, Australia; Bermuda; Santiago, Chile; Quito, Ecuador; Winkfield, England; and Madrid, Spain. A transportable station is located at NASA's Dryden Flight Research Center, California, for support of the Shuttle program. Smaller transportable stations will be located at New Smyrna Beach, Florida and Bangor, Maine, for support of the early Shuttle missions. An engineering test and network system training facility at the Goddard Space Flight Center is also maintained and operated as part of the Spaceflight Tracking and Data Network.

The Spaceflight Tracking and Data Network is currently providing support for an average of nearly 50 automated applications and space sciences spacecraft. Examples of significant missions being supported include the Earth Resources Technology Satellites (Landsat-2 and 3); four Applications Technology Satellites (ATS 1, 3, 5 and 6); the Heat Capacity Mapping Mission; the Orbiting Astronomical Satellite-3; two High Energy Astronomical Observatories (HEAO-1 and 2); Atmosphere Explorer (AE-5), Nimbus 5, 6, and 7; Geodynamics Experimental Ocean Satellite (GEOS-3); the International Sun Earth Explorers (ISEE 1, 2 and 3); and the International Ultraviolet Explorer.

Upcoming missions to be supported by the network include HEAO-C, the Magnetic Field Satellite (MAGSAT), the Solar Maximum Mission, and the Space Shuttle Orbital Flight Tests. The overall spacecraft support workload of the Spaceflight Tracking and Data Network is projected to average approximately 50 spacecraft during FY 1980.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease of $.8 million is a net reduction resulting from allocating to Tracking and Data Acquisition $1 million of the unspecified Congressional reduction in the FY 1979 funding requirements. This is accommodated by the earlier than planned deactivation of USNS Vanguard tracking ship after a thorough review of support requirements for the Shuttle orbital flight tests. In addition there was an unanticipated increase for Skylab support, a requirement to extend operation of the Smithsonian Astrophysical Observatory laser network beyond the planned termination date and also a decline in the value of the United States dollar affecting operations overseas.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 funding requirements for the Spaceflight Tracking and Data Network Operations provide for the maintenance and operation of the network and control center facilities, as well as the related logistics, network planning, scheduling, documentation, and computer programming costs associated with the around-the-clock operation of the network. Since these operations are manpower intensive the projected increase from FY 1979 to FY 1980 is due largely to continuing worldwide inflation. Some additional network support costs

for the Shuttle orbital flight tests are also projected in FY 1980. It is also planned to provide a ground back-up recording capability for Landsat-3 support in the event of failure of the onboard Landsat-3 tape recorders. The operation of this capability will insure a continued flow of Landsat-3 data until Landsat-D can be launched.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Deep Space Network Operations.....	46,570	49,800	49,800	55,600

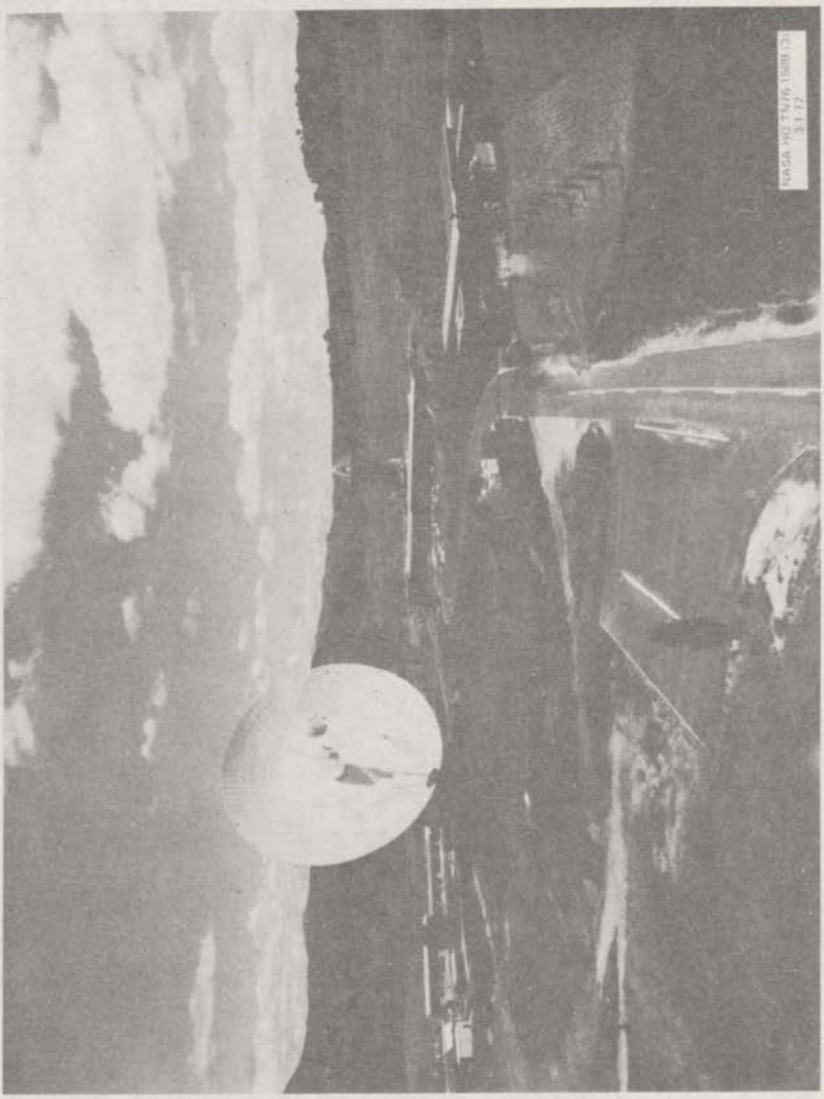
OBJECTIVES AND STATUS:

The primary function of the Deep Space Network is to support planetary and interplanetary space flight missions. The Deep Space Network provides the vital two-way communication link by which the distant spacecraft are controlled and scientific data are acquired. As the planetary missions become more complex and flight distances continue to increase, this network requires systems, software, and operational techniques that push the state-of-the-art in telecommunications.

The Deep Space Network stations are located at Goldstone, California; Canberra, Australia; and Madrid, Spain. The stations consist of one 64-meter and two 26-meter diameter antennas at each location, except at Goldstone where one of the 26-meter antennas has been expanded to 34 meters. Similar modifications are currently underway to provide the same configuration at the two overseas locations. The three locations are approximately 120° apart in longitude and permit continuous viewing of the planetary spacecraft. A centralized control center for the network is located at the Jet Propulsion Laboratory in Pasadena, California. JPL has field management for the network. Figure 2 depicts the 64-meter antenna facility complex at Canberra, Australia.

The current workload in the Deep Space Network consists of the seven on-going Pioneer spacecraft (Pioneers 6-11, and Pioneer-Venus), the three Viking spacecraft (one orbiter and two landers), the two Helios missions, and the two Voyager spacecraft. Support of these missions will continue during FY 1980 except for the Viking orbiter.

The Pioneer Venus orbiter/probe mission provided an excellent test of the Deep Space Network (DSN) capabilities when the network successfully supported simultaneously five vehicles (four probes plus the main bus) as they entered the Venusian atmosphere. Data was obtained from all five vehicles through their descent into the hot Venusian atmosphere for the entire period they were able to transmit data. The Pioneer Venus orbiter spacecraft is continuing to be supported by the DSN and returning excellent data.


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Of the older Pioneer spacecraft, Pioneer 10 is already over 2.5 billion kilometers from Earth and is proceeding on a path that will take it beyond the solar system. Pioneer 10 continues to be the most distant human made object ever communicated with and each time data is received, a new communications record is established. The Pioneer 11 spacecraft, some 1.1 billion kilometers from Earth, is also being tracked during its journey to the planet Saturn which it is scheduled to fly by during the third quarter of calendar year 1979. The Pioneer 6-9 spacecraft are provided support for coverage of special events such as solar conjunction. The two Helios missions are continuing their orbit about the Sun as they gather data on the solar plasma. The three Viking spacecraft are now in an extended mission phase.

Taking advantage of a rare alignment of the outer planets Jupiter and Saturn, two Mariner-class spacecraft, Voyager 1 and 2, were launched in 1977. Preparations have been completed in the Deep Space Network to provide the necessary support for the Jupiter encounter phase which occurs in March and July 1979 for Voyager 1 and 2, respectively. As is typical of planetary missions, the two Voyager spacecraft will require support for several years during their flight to Jupter and Saturn.

The Deep Space Network facilities are also used for ground-based measurements in support of experiments in planetary radar mapping and in the field of radio astronomy. The ultrasensitive network antennas are being used in an attempt to learn more about the mysterious pulsar high energy sources and other interstellar phenomena. During FY 1980, support of these radio astronomy experiments will continue on a non-interference basis to the planetary flight missions.

In addition to the Voyager missions, the upcoming Deep Space Network workload also includes preparation for support of the Galileo and International Solar Polar Missions. These support preparations require thorough and complex testing, training, engineering and software effort and compound the difficulty of overall support planning and execution since such preparations must be carried out at the same time that the network is supporting the extensive and continuous on-going workload described above.

BASIS OF FY 1980 ESTIMATE:

Deep Space Network operations funds provide for the contractor maintenance and operation of the network facilities, network control center, and the network support and engineering effort associated with the operation of the network. The funds requested for FY 1980 are based upon the on-going workload, including the Pioneer 6 through 11 missions and the Pioneer Venus mission, and the Voyager missions.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Aeronautics and Sounding Rocket Support Operations....	4,982	4,900	4,900	4,800

OBJECTIVES AND STATUS:

Instrumentation systems are maintained and operated for the sounding rocket, balloon, small satellite, and aeronautical programs conducted by the Wallops Flight Center and the aeronautical flight research programs of the Dryden Flight Research Center. These instrumentation systems include general purpose tracking, telemetry, data handling, and communications systems, as well as special purpose optical equipment.

The sounding rocket program continues to be very active, with over three hundred launches last year, ranging from the smaller meteorological rockets to the larger Scout rockets. The majority of these sounding rocket launches are conducted at the Wallops Flight Center. This workload is expected to remain at approximately the same level in FY 1980. In addition to the continuing sounding rocket, balloon and aeronautical program activities, Wallops will provide specialized tracking, evaluation, and calibration services for the launch phases of the Shuttle orbital flight tests.

The Dryden Flight Research Center (DFRC) operates the Aerodynamics Test Range, consisting of facilities at DFRC and an uprange site at Ely, Nevada. These facilities are composed of precision radar tracking, telemetry, and communications equipments, which are used to monitor and control high performance aircraft research and development programs of both NASA and the Air Force. In the first half of 1979, NASA plans to turn the operations of the Ely site over to the Air Force for support of their programs. This action is possible due to the completion of the YF-12 flight program. Various aircraft research and technology projects are supported by the Aerodynamics Test Range. Aircraft flown in these flights include the F-111, F-104, F-15, F-8 and remote piloted vehicles including Highly Maneuverable Aircraft Technology (HiMAT). Tracking and data acquisition support of the Shuttle orbital flight tests is planned at the Dryden Flight Research Center for FY 1979 and FY 1980.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 funding requirements support the sounding rocket launches and the Aerodynamics Test Range activities. The request also includes the anticipated effect of escalation and the necessary resources to support the initial Shuttle orbital flight test landings at the Dryden Flight Research Center.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Communications Operations	27,931	37,900	34,800	39,800

OBJECTIVES AND STATUS:

NASA's global communications network (NASCOM) interconnects by means of leased voice and data circuits the tracking and data acquisition facilities which support all flight projects. NASCOM also links together such facilities as launch areas, test sites, and mission control centers. The Goddard Space Flight Center operates the NASCOM and serves as its major switching control point. In the interest of economy, reliability, and full utilization of trunk circuitry, subswitching centers have been established at key domestic and overseas locations. Figure 3 is a pictorial representation of NASCOM.

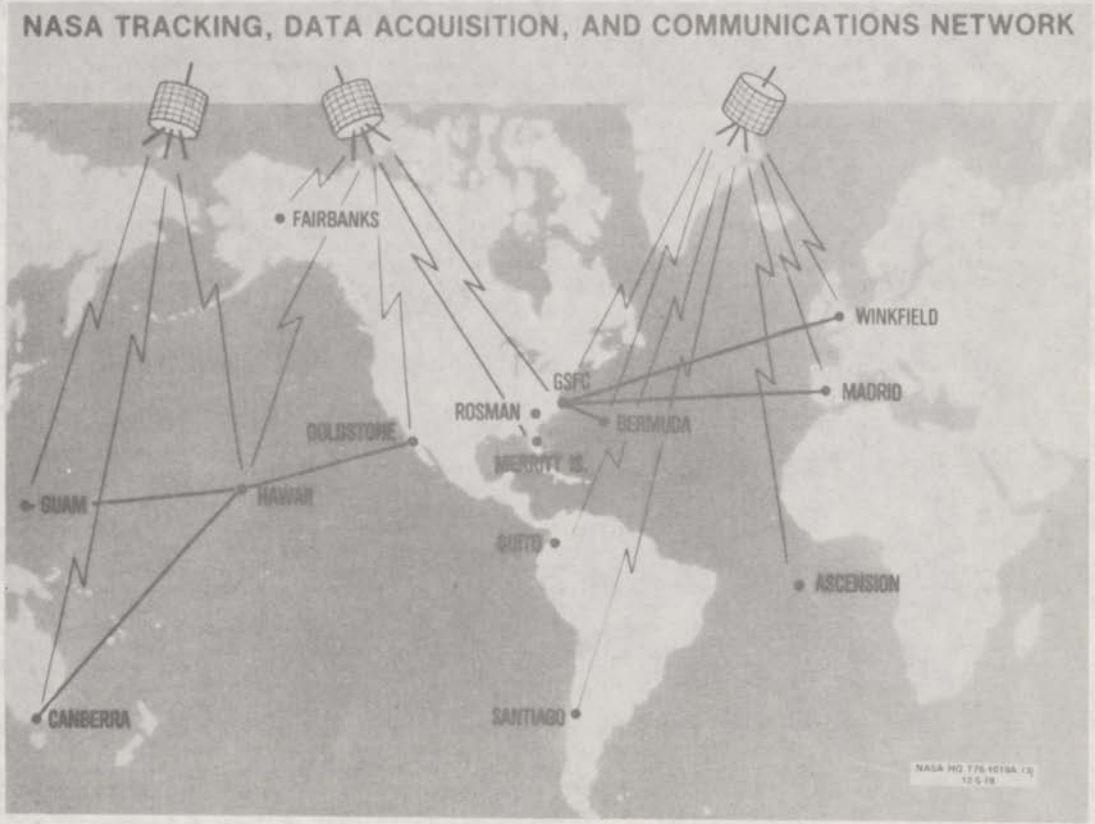
To an increasing extent, the NASA flight projects are requiring the transfer of greater amounts of data between the mission control centers and the tracking sites because of the need for real time control of the spacecraft and on-board experiments. In addition, there is a requirement to provide increasing amounts of experiment data more quickly to the users for analysis.

In order to meet high data transfer rate requirements, NASA is increasing its utilization of digital techniques in providing communications support. The availability of this technology allows for a greater amount of data to be sent over conventional communication circuits. Also, circuits capable of transferring data at increasingly higher rates are becoming available from the common carriers at reasonable costs. Consequently, the techniques of sending data directly from a spacecraft, through a tracking station without manipulation, to a mission or project control center has become economically attractive. This approach, referred to in the communications field as a "bent pipe" mode, simplifies the data handling systems at the tracking stations, thereby minimizing the operation and maintenance activities at those locations. As a result, the trend toward the direct transfer of data from the spacecraft to the control center via high data rate communications links is expected to continue.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease of $3.1 million in the FY 1979 funding level resulted from two factors: (1) the delay in the Shuttle orbital flight test schedule which, in turn, allowed for a delay in ordering up the wideband communications circuits required for Shuttle support and (2) lower than originally estimated prices for some overseas wideband circuits.

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BASIS OF FY 1980 ESTIMATE:

The FY 1980 funding requirements for communications operations will provide for the circuits and services required to operate and maintain the NASCOM. International communications satellites will permit the extension of additional digital wideband services to all overseas tracking stations. These services will provide for the near real time transfer of data for all on-going flight programs.

The major reason for the increased requirements in FY 1980 is due to the support requirements for the Shuttle flights. This project requires a full year of wideband communications circuits throughout virtually the entire network of stations. Wideband service will also be initiated near the start of the fiscal year to support the Tracking and Data Relay Satellite System (TDRSS) facility testing phase.

The operation of the switching centers and technical control facilities is a continuing function assuring high reliability and efficiency in the use of the various types of communications services available to NASCOM from the common carriers. Funds are included in the FY 1980 request to cover the cost escalation associated with the operation and maintenance of these facilities.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Data Processing Operations.....	28,931	31,700	33,000	34,400

OBJECTIVES AND STATUS:

Information received in the form of tracking and telemetry data from the various spacecraft must be processed into a usable form for the day-to-day spacecraft operations and for analyzing the experiment data acquired by the spacecraft. This data processing function is performed for a wide variety of programs, which range from the small Explorer satellites to large and complex Solar/Astronomical Observatories and the Landsat Earth Resources Technology Satellites.

Tracking data are processed to provide orbital elements which are used to compute spacecraft positions. These functions are essential for the real time control of spacecraft, for determining when the spacecraft will be passing over the stations so data can be acquired, and for providing precise information that can be used by the scientific experimenters to determine where in the trajectory of the spacecraft the scientific measurements were made. Telemetry data must be processed to: (a) separate the information obtained from various scientific experiments aboard the spacecraft; (b) consolidate information from each experiment;

(c) determine spacecraft attitude; and (d) correlate these measurements with the position data. Processed data are the primary product of the spacecraft missions, and it is through reductions and analyses of these data by the experimenters that the planned objectives are achieved.

In addition to the actual processing of the data, upcoming projects require extensive premission orbit studies, including spacecraft position and attitude predictions. Studies are also required to develop operational sequences and procedures to be used during the actual operation of these complex spacecraft.

Two facilities, the Image Data Processing Facility and the Telemetry On-Line Processing System (TELOPS) have been established at Goddard Space Flight Center to process different types of data.

The Image Data Processing Facility, initially established for the support of the first Earth Resources Technology Satellite (LANDSAT-1) to handle imagery data, now supports the second and third LANDSAT spacecraft. Beginning in the second quarter of FY 1979 these spacecraft are supported with a new all-digital system using computer compatible tapes to reduce the time required to provide data to users. The operational requirement for this facility is expected to continue through the next several years for support of the currently operational and/or approved programs including Nimbus 7, Synchronous Meteorological Satellites, Heat Capacity Mapping Mission, and the upcoming Solar Maximum Mission.

The telemetry processing facility which has handled the conventional, nonimagery data, was reconfigured in FY 1978 when the Telemetry On-Line Processing System (TELOPS) was phased in. This reconfiguration resulted in a change from a tape-oriented system to an automated on-line electronic mass storage system. TELOPS receives satellite data in digital form from the tracking stations via NASCOM communication lines and is able to store up to six months of telemetry data on-line, thus eliminating most of the tape and tape handling operations within the old processing facility.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The increase of $1.3 million in the FY 1979 funding level resulted from extension of support for the GEOS-3 mission, greater than expected costs associated with bringing TELOPS into full operation and a delay in the operational date for the all-digital system in the Image Processing Facility.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 budget requirements include funds to operate the Image Processing Facility and the Telemetry On-Line Processing System to process data from currently orbiting satellites, as well as data from the satellites scheduled to be launched during the period. The scientific requirements for the acquisition and processing of data from the older satellites are under continuing review, and support for older missions

is terminated or curtailed as mission objectives are achieved or when the experiment data is no longer useful or cost effective to acquire and process.

Software procurement activities have been initiated for support of upcoming space science and applications spacecraft such as the Space Telescope and Dynamic Explorers, as well as Spacelab. The activities cover spacecraft orbit and attitude control and related data processing requirements which require additional funding for FY 1980. Software effort is also required to develop the necessary programs to accommodate the TDRSS/free flyer mode of operation.

As in other areas of operations, escalation is a significant factor contributing to the increased funding level requested for FY 1980 over FY 1979.

BASIS OF FUND REQUIREMENTS:

SYSTEMS IMPLEMENTATION

The objectives of the NASA tracking and data systems implementation program are to maintain the existing ground support capability at a high level of proficiency and reliability in order to meet the aggregate support needs of the many and varied space missions, and to provide augmentation to this capability, as necessary, to meet the special requirements of individual flight projects. These ground support systems consist of the tracking and communications networks, control centers, data processing facilities and aeronautics and sounding rocket instrumentation.

The system implementation program encompasses the engineering, design and procurement of the necessary equipment, subsystems, and systems in response to the requirements of the various flight missions and other research projects. It also includes related documentation and basic software, the provisioning of large module spares, and the acceptance testing, integration and checkout of equipment.

The majority of the FY 1980 funding requested is needed to maintain the required level of operational proficiency and reliability of network systems through the replacement of obsolete and worn-out equipment. Modification and augmentation of existing systems are also necessary to maintain compatibility with changes in associated onboard spacecraft communications systems and to improve the utilization and efficiency of network systems. In addition, FY 1980 funds are also required to continue the implementation of new capabilities for upcoming approved missions, including the International Solar Polar Mission, Galileo, Space Telescope, Shuttle, and Spacelab programs.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network	18,632	13,000	13,000	17,000
Deep space network	11,640	14,800	12,500	15,100
Aeronautics and sounding rocket support	3,095	3,500	3,500	3,700
Communications	3,433	5,100	5,100	3,700
Data processing	3,600	4,900	6,400	6,900
Total	40,400	41,300	40,500	46,400
Spaceflight Tracking and Data Network Systems Implementation	18,632	13,000	13,000	17,000

OBJECTIVES AND STATUS:

The Spaceflight Tracking and Data Network Systems Implementation program encompasses the procurement and implementation of systems and services necessary to sustain an effective capability for reliable support of ongoing scientific and applications satellite missions, to assure network capabilities for efficient tracking, command, and data acquisition support for all NASA manned and unmanned earth orbital missions, and to meet new support requirements for spacecraft to be launched in the near future. Implementation of these capabilities is vital to the success of NASA's spaceflight missions.

Employing systems implemented in past years, the network is currently supporting many missions with highly complex requirements for tracking, data acquisition, and command. Among these are the International Sun Earth Explorers (ISEE 1, 2, and 3), the High Energy Astronomy Observatories (HEAO 1 and 2), LANDSATS 2 and 3, Nimbus 6 and 7, and the Laser Geodynamic Satellite (Lageos). Network and control center systems are in the final stages of implementation for upcoming new missions such as the Space Shuttle Orbital Flight Tests, Stratospheric Aerosols and Gas Experiment, Solar Maximum Mission, and the Magnetic Field Satellite (Magsat). Plans and procurements are also underway to meet support requirements for future missions such as the Space Shuttle operational flights, Spacelab, LANDSAT-D, and the Space Telescope.

BASIS OF FY 1980 ESTIMATE:

Equipment modifications are required in the network and control centers in FY 1980 to maintain the required level of proficiency for support of a diverse and demanding workload and to assure the reliability of the network systems. Accordingly, funds are required for replacement of worn-out systems with more reliable units, for equipment modifications to correct operational deficiencies, and for equipment to be used in operational control of the network. The funds requested also provide for procurement of subsystem spares, for the provision and modification of test equipment, and for minor equipment modifications resulting from changes in support requirements from one mission to the next.

The operational flights of the Space Transportation System (STS) will employ the Tracking and Data Relay Satellite System (TDRSS) for orbital tracking and command and for data, television, and voice communications. A comprehensive capability for prelaunch testing and launch support of Shuttle and for compatibility testing of Shuttle and STS payloads with TDRSS is being installed at the Merritt Island, Florida, network station. Funds are requested in FY 1980 to complete the Merritt Island station TDRSS compatibility test capability and to complete tne STS and STS payload telemetry and command monitoring systems at the TDRSS ground station at White Sands, New Mexico. Funds are also included for the continued implementation of mobile compatibility test vans to be used for prelaunch free flyer spacecraft/TDRSS compatibility testing.

In addition, funds are requested to procure a transponder test set to maintain and calibrate the TDRSS bilateration tracking systems funded in FY 1978 and FY 1979. The bilateration tracking system is required to obtain precise position information on the TDRSS. Precise position of the TDRSS spacecraft is necessary in order to calculate precise orbits of the spacecraft being tracked by TDRSS. Data from the bilateration tracking systems will be processed by the Goddard Space Flight Center employing existing orbit computation capabilities to obtain precision orbits for TDRSS supported spacecraft in the same manner as orbits are presently calculated using data obtained by the network ground stations.

In FY 1980, activities will continue to design and implement a new control center for the Space Telescope. This work will be conducted in concert with the development of the Science Institute (funding by Office of Space Science) to minimize the design cost for both hardware and software systems as well as to facilitate testing and other operations.

Tape recorders for LANDSAT-3 support will also be procured in FY 1980. These recorders will be located at several foreign locations as a backup recording capability to insure a continued flow of LANDSAT-3 data in the event of failure of the LANDSAT-3 onboard tape recorders.

To meet the mission control workload in the 1980's, a new approach to control center design has been initiated in FY 1979. This approach involves techniques for rapid configuration of control center equipment to meet the requirements of a particular mission. The overall objective of the new design is to permit the sharing of resources to improve equipment utilization and to decrease the number of software and operations personnel. In Fiscal Year 1980, the necessary complement of computers will be purchased and the integration of a "cluster" of control centers undertaken.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Deep Space Network Systems Implementation.....	11,640	14,800	12,500	15,100

OBJECTIVES AND STATUS:

The Deep Space Network is responsible for recovering science data from and providing the capability for remote operation of planetary and interplanetary spacecraft. The systems and facilities required to accomplish this are highly specialized and include Deep Space stations with their large aperature antennas (up to 64-meter diameter), ultrasensitive receivers, and high power transmitters. Advanced data handling systems are also required both at the stations and in the network control center.

The Deep Space Network Systems Implementation program provides for procurement of the systems and related services to be used in this network to assure that its capabilities keep pace with ongoing and upcoming approved planetary mission support requirements. It also provides for the replacement of obsolete equipment in order to improve the performance, reliability, and maintainability of the network. The equipment and techniques funded under this program are a major contributor to: improvements in spacecraft navigation accuracy; the successful conduct of increasingly complex experiments; and the ability to receive increasing amounts of scientific information from planetary spacecraft at ever increasing distances from Earth. The need for dedicated network support during many time-critical mission events combined with the increasing communication distances and the demand for greater ground navigation precision, requires a continuing effort to extend network capabilities, performance, and reliability.

During FY 1980 the network will be nearing completion of the provisioning of 3 of its 26-meter antennas with an X-band capability and making final preparations for the Voyager Saturn encounters which occur in FY 1981.

At the same time increased effort will be expended towards preparing the network for the complex and difficult tasks of supporting the launch, Mars encounter, and cruise phase of the Galileo mission, and the dual spacecraft NASA-European Space Agency International Solar Polar Mission.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The decrease of $2.3 million from the FY 1979 budget estimate resulted from the Congressional appropriations action which deleted funding for the search for extraterrestrial intelligence (SETI) research and imposed a general reduction which necessitated an additional delay in the replacement of obsolete computer equipment at the DSN stations.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 funding will provide for completion of a portion of the navigation improvements required for Voyager Saturn encounter support are being deferred from FY 1979. FY 1979 funds originally planned for this purpose are being used for network modifications necessitated by an anomaly in one of the Voyager spacecraft's receiving systems. Additional funding for Voyager support has also become necessary due to an adjustment in the Saturn encounter trajectory changing coverage requirements so that microwave equipment previously planned for implementation at only the 64-meter station in Spain will also be necessary at the 64-meter station in Australia.

As part of a phased program initiated in 1976, one subnet of 26-meter antenna facilities is being augmented with an X-band reception capability, which includes an expansion of the antenna aperature to 34 meters. FY 1980 funds will complete these modifications, thus providing a 34-meter antenna with X-band reception capability at the three major DSN locations to provide relief for the extremely overloaded 64-meter facilities. These antennas with their expanded telecommunications capability are initially required for support of the post-Jupiter cruise phase of the Voyager mission and will also be used in combination with the 64-meter antennas to significantly increase the amount of scientific data which can be returned from the Voyager Saturn encounters. They will also provide a vital telecommunications capability for the International Solar Polar Mission and the cruise phases of the Galileo mission.

The development of Very Long Baseline Interferometry (VLBI) tracking techniques and the increased need for planetary missions to obtain high accuracy ground navigation places a significant support workload on the 64-meter stations which are the only facilities presently equipped for this task. Commencing in 1982, the network will be required to support the Galileo flyby of Mars enroute to Jupiter and the Voyager cruise phase to Uranus, both of which will use VLBI for navigation. The critical Mars flyby in particular, will require support by the 64-meter antenna facilities, leaving little if any support time for Voyager. Therefore, FY 1980 funds will be used to initiate the necessary modifications at the 34-meter antenna facilities so that this support workload can be shared with the 64-meter antenna facilities.

The replacement of obsolete data handling computers which was delayed from the FY 1979 budget will be initiated in FY 1980. The computers presently in the network were originally installed in 1964 and new replacement components are no longer available. FY 1980 funds are also required to maintain the high level of reliability required to support critical one-time mission events. This can only be accomplished through a continuing program of spares provisioning, maintenance support and minor equipment modifications to improve reliability, upgrade equipment performance and to provide for the interfacing of existing equipment with the new systems being added in the network.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Aeronautics and Sounding Rocket Support Systems Implementation	3,095	3,500	3,500	3,700

OBJECTIVES AND STATUS:

The aeronautics, balloon, and sounding rocket programs are supported at the Wallops Flight Center in Virginia, and the Dryden Flight Research Center in California.

The aeronautics program support at Wallops consists of model and/or instrumentation drop tests utilizing helicopter or fixed-wing aircraft, aircraft noise abatement projects, slow speed landing techniques for jet aircraft, antiskid tests on grooved runways, vertical/short takeoff and landing (V/STOL), terminal area research, microwave landing system development tests, collision avoidance programs and remote (airborne) sensing developments in support of the earth resources programs.

The sounding rocket programs supported at Wallops cover all the atmospheric and space disciplines in which research is undertaken, utilizing a family of launch vehicles varying in size and power from the small meteorological rockets to the 72-foot Scout with orbital capability. Approximately 300 sounding rockets are launched annually from Wallops Island and remote sites around the world, carrying experiments in the field of Aeronomy, Energetic Particles, Ionospheric Physics, Meteorology, and Solar Physics. Of particular interest is the current effort to measure the effect of aerosols on the protective layer of ozone in the upper atmosphere which filters out harmful solar radiation and the measurement of other compounds such as nitric oxide as part of the environmental observations program.

To provide instrumentation support to these programs, fixed and mobile ground support equipments are provided by Wallops. To maintain these equipments, spare and replacement parts are required, as well as some non-recoverable flight hardware such as on-board antennas and transponders. To meet specific test requirements, modifications and augmentations of selected telemetry, communications, tracking, command, and data handling systems are required. In addition, the mobile equipment must be periodically refurbished and modified to meet remote site requirements such as the ongoing meteorological program in cooperation with several nations, including Argentina, Brazil, and Spain.

The aeronautical research and technology programs supported by the Dryden Flight Research Center (DFRC) consist of high altitude and terminal area tests involving high performance aircraft such as the F-111, F-15, F-104, F-8, Remote Piloted Vehicles including HiMAT, and various other aircraft and helicopters. Dryden Flight Research Center was responsible for the Approach and Landing Tests for the Shuttle Orbiter in 1977 and will support the Orbital Flight Tests beginning in 1979. The ground support equipment is located on the Aerodynamics Test Range, which consists of stations at the Dryden Flight Research Center and Ely, Nevada. Operational responsibility for the Ely, Nevada station will be transferred to the Air Force in early 1979. High precision radar, telemetry data handling, and associated timing, communications, and command systems are maintained and modified to meet the changing requirements of the approved flight projects.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 funding requirements will provide the sustaining equipment and modifications to support the sounding rocket and aeronautics program described above.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Communications Systems Implementation.....	3,433	5,100	5,100	3,700

OBJECTIVES AND STATUS:

The objective of the Communications System Implementation program is to provide the necessary capability in NASA's global communications network (NASCOM) to meet new program support requirements, to increase the efficiency of the network, and to keep NASCOM at a high level of reliability for the transmission of data.

NASCOM interconnects the tracking and data acquisition facilities which support all flight projects. NASCOM also links together such facilities as launch areas, test sites, and mission control centers.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 budget request provides for network equipment to increase the performance in handling data, continuing with the automatic switching capability for TDRS data and the data recall system for error control on overseas high data rate lines.

Also included in the FY 1980 budget request are funds for a continuing effort to improve the data transmission and performance monitoring capabilities of the NASCOM as the use of digital techniques expand to handle the higher data rates of the flight projects. The use of the digital mode requires specialized and automated equipment to transmit the data over the leased communications circuits at the rates utilized by NASA.

With the use of digital techniques, it becomes increasingly cost effective to use wideband circuits in NASCOM to "bent pipe" data from the stations to the control centers. Wideband terminal and interface equipment will continue to be procured in FY 1980 as the common carriers make available a greater variety of wideband communications services at an economical price.

To maintain system reliability, a continuing program to procure replacement parts, spares, test and monitoring equipment is necessary. Funds for this purpose are included in the FY 1980 request.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Data Processing Systems Implementation.....	3,600	4,900	6,400	6,900

OBJECTIVES AND STATUS:

The Data Processing Systems Implementation program provides for the procurement of equipment and related services to sustain the large computer complexes at the Goddard Space Flight Center (GSFC) which support both the operational and payload requirements of space missions. To meet operational requirements these computer complexes, utilizing sophisticated software programs, determine spacecraft attitude and orbit, generate commands to the spacecraft and provide the status of onboard subsystems. In support of spacecraft payloads, the computer systems process the data from science and applications experiments for subsequent transfer to the experimenters.

Several significant activities in this program are underway at GSFC. The Telemetry On-Line Processing System (TELOPS) became operational during 1978 and is now successfully supporting a number of spacecraft,

including the recently launched HEAO-2. The Image Processing Facility has been augmented at GSFC and has begun to produce output products for LANDSAT, Heat Capacity Mapping Mission, and Nimbus-7. Procurement of a computer system will be initiated during FY 1979 to replace the aging system that provides a metric tracking data base for orbit computation. Modifications will also be started so that TELOPS can handle the data formats for the early Spacelab missions.

CHANGES FROM FY 1979 BUDGET ESTIMATE:

The increase of $1.5 million in the FY 1979 funding level resulted from the requirement to implement an interim Spacelab data processing capability for the early Spacelab missions.

BASIS OF FY 1980 ESTIMATE:

The FY 1980 budget request will provide initial funding for partial replacement of the existing computer complex at the Goddard Space Flight Center which provides real time support to the many NASA spacecraft. Included in the support are such critical activities as real time attitude and orbit determination, memory management for onboard computers, and flight maneuver control. By FY 1980, this computer complex will be approximately 15 years old. Not only are the hardware and software maintenance becoming more difficult and expensive, but the growing unreliability creates an increasing risk to reliable spacecraft operation. Further, their system architecture requires greater software expenditures to adapt to new missions. Funds are also requested to complete certain system procurements, including the interim Spacelab data processing facility and the Flight Maneuver Operations Control (FMOC) backup system.

Under the sustaining program, there is a continuing requirement to procure and maintain adequate supplies of spare parts, replace failure prone and high maintenance electronic modules, provide test equipment and undertake minor modifications and hardware fabrication associated with new equipment installation and equipment reconfiguration.

BASIS OF FUND REQUIREMENTS:

ADVANCED SYSTEMS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
Advanced Systems	9,316	9,900	9,900	10,600

OBJECTIVES AND STATUS:

Under the Advanced Systems program studies and developments are conducted (1) to obtain new and improved capabilities to meet the needs of upcoming missions and programs, and (2) to investigate advanced techniques and to identify the required technology for support of upcoming missions, and (3) perform ground systems studies to determine, for example, the lowest life-cycle costs for support of future space missions.

BASIS OF FY 1980 ESTIMATE:

One of the more specific objectives of the Advanced Systems program which characterize the efforts planned for FY 1980 is to improve the ground-based navigation accuracy of the Deep Space Network (DSN). Prior advanced systems efforts have resulted in studies and experiments which now make it possible to have an increased navigation accuracy in support of planetary missions. Current accuracy of the DSN for tracking and guidance of planetary missions is approximately 100 Km out to the distance of Mars. Ground-based navigation for future planetary spacecraft requires tracking to about 5 to 10 Km accuracy at Mars distance and 100 Km at the outer planets. Missions of the future that require navigation accuracy improvement include outer planet gravity-assist swingbys and orbiters, outer planet satellite flybys and probes, and non-ballistic, low thrust missions.

Investigations involving the use of Very Long Baseline Interferometry (VLBI) now promise further improvements in ground-based navigation accuracy by a factor of 100 under some conditions. Several new navigation techniques based on VLBI have been or are under development. One, for example, will be demonstrated in 1979 during the Voyager encounter at Jupiter. In this demonstration navigation accuracy will be provided through measurement of angular position difference between spacecraft and a succession of well established quasar star positions. This system will be used later in the Voyager encounter with Saturn and the critical Galileo Mars flyby.

Also under development for experimental use during the Galileo Mars flyby is a further refinement in VLBI techniques which will allow a factor of 10 improvement in ground-based navigation accuracy over the sytem previously described for Voyager. Success with this experiment will enable the network to pinpoint the location of Galileo to about 10 Km (6.2 miles) as it flies by Mars. Such precision will reduce the number of mid-course corrections, with resultant savings in spacecraft fuel. This fuel conservation will permit the flight project to maximize the number of Galileo encounters with the satellites of Jupiter in the later phases of the mission. Under the Advanced Systems program, this technique will continue to be evaluated for future applications particularly with respect to ultra-precise orbiter mission requirements.

Laser ranging technology used in the tracking of satellites such as LAGEOS is also being developed for space applications particularly the Earth crustal dynamics program. Best accuracy now obtained is 10-50 centimeters, but 2-5 centimeter accuracy is needed for our mobile ranging stations in order that geologists can better study the Earth's crust and its relationship to earthquakes.

Ground-based technology for radio telecommunications will also be developed in order to support future spacecraft command and data acquisition requirements. Future planetary missions require rates in excess of 60 kilobits (more than twice current capability) from Saturn, a distance of approximately 1.5 billion kilometers from Earth. Future earth orbital missions with new high resolution sensors for monitoring the Earth's surface and its environment require telemetry rates approximately 10 times current network support capabilities. To meet these needs advanced systems work will be conducted on more efficient antenna feeds and configurations, high sensitivity receiving systems, improved microwave component technology, and methods to monitor and avoid increasing radio frequency interference being experienced from sources outside the area of our stations.

Methods of providing tracking and data acquisition support which are more cost-effective than those currently used will also be investigated. These include very small antennas for broad beam surveillance of spacecraft to release large facilities from routine acquisition of housekeeping telemetry; techniques for automation of station and control center functions; the desirability and feasibility of using an Earth orbiting satellite to relay data from deep space missions and localized use of fiber optics for wideband data switching and transmission.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

GENERAL STATEMENT

The Construction of Facilities (CoF) appropriation provides for contractual services for repair, rehabilitation and modification of existing facilities; the construction of new facilities; the acquisition of related facility equipment; the design of facilities projects and advance planning related to future facilities needs.

The funds requested for 1980 provide for: the continuation of prior years' endeavors in meeting the facilities requirements for the Space Shuttle and Space Shuttle payloads; construction and modification of large aeronautical research and development facilities; construction, repair, rehabilitation, and modification of other facilities to maintain, upgrade and improve the usefulness of the NASA physical plant; and facility planning and design activities.

The projects and amounts reflected in this budget estimate for Space Shuttle and Space Shuttle payloads are time sensitive to meet specific milestones. The program for FY 1980 includes the fourth increment of funding for two large aeronautical facilities, the construction of a National Transonic Facility at the Langley Research Center and modification of the 40- x 80-Foot Subsonic Wind Tunnel at the Ames Research Center. Requirements for these and other aeronautical research and technology facilities are outlined in detail in the justifications that follow.

The FY 1980 program continues to meet the objectives of preserving and enhancing the capabilities and usefulness of existing facilities and to ensure safe economical and efficient use of the NASA physical plant. This request continues the necessary Rehabilitation and Modification Program as in prior years and introduces a new Repair program. The purpose of the Repair program is to restore facilities to a condition substantially equivalent to their originally designed capability. The minor construction program continues to provide a means to accomplish smaller facility projects which accommodate changes in technical and institutional requirements. This program also includes projects which continue NASA efforts to reduce the consumption of energy.

Funds requested for facility planning and design cover advance planning and design requirements for potential future projects, master planning, facilities studies, engineering reports and studies and the preparation of facility project design drawings and bid specifications.

The request for FY 1980 is $157,600,000, an increase of $10,100,000 above the appropriation for FY 1979. Outlays are estimated to be $155,200,000 in FY 1980, an increase of $1,700,000 over the estimate for FY 1979.

PROPOSED APPROPRIATION LANGUAGE

Construction of Facilities

For construction, *repair*, rehabilitation and modification of facilities, minor construction of new facilities and additions to existing facilities, and for facility planning and design not otherwise provided, for the National Aeronautics and Space Administration, and for the acquisition or condemnation of real property, as authorized by law, [$147,500,000] *$157,600,000*, to remain available until September 30, [1981] *1982*: *Provided*, That, notwithstanding the limitation on the availability of funds appropriated under this head by this appropriation Act, when any activity has been initiated by the incurrence of obligations therefor, the amount available for such activity shall remain available until expended, except that this provision shall not apply to the amounts appropriated pursuant to the authorization for *repair*, rehabilitation and modification of facilities, minor construction of new facilities and additions to existing facilities, and facility planning and design. *(42 U.S.C. 2451, et. seq.; Department of Housing and Urban Development—Independent Agencies Appropriation Act, 1979; additional authorizing legislation to be proposed.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

Program and Financing (in thousands of dollars)

Identification code 80-0107-0-1-999	Budget plan: amounts for construction of facilities actually programed			Costs and obligations		
	1978 actual	1979 estimate	1980 estimate	1978 actual	1979 estimate	1980 estimate
Program by activities:						
Direct program:						
1. Space transportation systems	64,880	31,070	31,450	50,081	54,600	37,800
2. Scientific investigations in space	6,410		4,250	8,131	5,500	3,200
3. Space and terrestrial applications	3,100			10	1,700	
4. Space research and technology				663	200	
5. Aeronautical research and technology	38,400	76,530	62,500	22,951	49,800	70,500
7. Supporting activity	49,550	39,900	59,400	39,293	47,000	54,300
Total direct program costs, funded	162,340	147,500	157,600	121,129	158,800	165,800
Reimbursable program:						
7. Supporting activity (reimbursable program cost)	2,159	305		1,157	6,600	1,600
Total program costs, funded	164,499	147,805	157,600	122,286	165,400	167,400
Change in selected resources (undelivered orders)				35,126	3,028	−4,400
10.00 Total obligations	164,499	147,805	157,600	157,412	168,428	163,000
Financing:						
11.00 Offsetting collections from: Federal funds	−2,159	−305		−2,159	−305	
21.40 Unobligated balance available, start of year: For completion of prior year budget plans:						
Direct				−80,353	−93,356	−73,556
Reimbursable				−6,942	−823	
24.40 Unobligated balance available, end of year: For completion of prior year budget plan:						
Direct				93,356	73,556	68,156
Reimbursable				823		
25.00 Unobligated balance lapsing				203		
Budget authority	162,340	147,500	157,600	162,340	147,500	157,600
Budget authority:						
40.00 Appropriation	160,940	147,500	157,600	160,940	147,500	157,600
42.00 Transferred from other accounts	1,400			1,400		
43.00 **Appropriation (adjusted)**	162,340	147,500	157,600	162,340	147,500	157,600
Relation of obligations to outlays:						
71.00 Obligations incurred, net				155,253	168,123	163,000
72.40 Obligated balance, start of year				97,187	128,061	142,684
74.40 Obligated balance, end of year				−128,061	−142,684	−150,484
77.00 Adjustments in expired accounts				−121		
90.00 Outlays				124,258	153,500	155,200

Note.—Reconciliation of budget plan to obligations

	1978 actual	1979 estimate	1980 estimate
Total budget plan	162,199	147,805	157,600
Deduct portion of budget plan to be obligated in subsequent years	63,921	26,850	28,700
Add obligations of prior year budget plans	66,844	47,473	34,100
Total obligations	165,412	168,428	163,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

SUMMARY OF THE BUDGET PLAN BY LOCATION

Location	FY 1978	FY 1979 (In Dollars)	FY 1980
Ames Research Center	---	9,770,000	2,900,000
Hugh L. Dryden Flight Research Center	420,000	---	1,500,000
Goddard Space Flight Center	4,500,000	5,640,000	---
Jet Propulsion Laboratory	2,830,000	4,630,000	---
Lyndon B. Johnson Space Center	2,540,000	---	1,760,000
John F. Kennedy Space Center	2,130,000	---	2,210,000
Langley Research Center	1,770,000	6,500,000	7,980,000
Lewis Research Center	860,000	6,140,000	5,720,000
George C. Marshall Space Flight Center	---	---	3,540,000
National Space Technology Laboratories	620,000	---	---
Wallops Flight Center	---	---	1,100,000
Large Aeronautical Facilities	37,000,000	56,100,000	45,900,000
Various Locations	1,750,000	---	---
Space Shuttle Facilities	64,880,000	31,070,000	31,450,000
Space Shuttle Payload Facilities	6,410,000	---	4,250,000
Repair	---	---	12,000,000
Rehabilitation and Modification	18,900,000	12,800,000	19,790,000
Minor Construction	5,950,000	4,200,000	3,500,000
Facility Planning and Design	11,780,000	10,650,000	14,000,000
Total Plan	162,340,000	147,500,000	157,600,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

	FY 1978	FY 1979 (In Dollars)	FY 1980
SUMMARY OF THE BUDGET PLAN BY COGNIZANT OFFICE			
Office of Space Transportation Systems	71,290,000	31,070,000	31,450,000
Office of Space Science	---	---	4,250,000
Office of Aeronautics and Space Technology	37,980,000	76,530,000	62,500,000
Office of Space Tracking and Data Systems	3,150,000	---	---
Office of Space and Terrestrial Applications	3,100,000	---	---
Office of Management Operations	10,190,000	9,190,000	---
Office of the Comptroller	36,630,000	30,710,000	59,400,000
Total Plan	162,340,000	147,500,000	157,600,000

SUMMARY OF THE BUDGET PLAN BY SUBFUNCTION

Code No.	Title			
253	Space Flight	64,880,000	31,070,000	31,450,000
254	Space Science, Applications and Technology	9,510,000	---	4,250,000
255	Support Space Activities	49,550,000	39,900,000	59,400,000
(250)	Subtotal, General Science, Space and Technology	123,940,000	70,970,000	95,100,000
402	Air Transportation	38,400,000	76,530,000	62,500,000
	Total	162,340,000	147,500,000	157,600,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

BUDGET PLAN BY LOCATION AND PROJECT

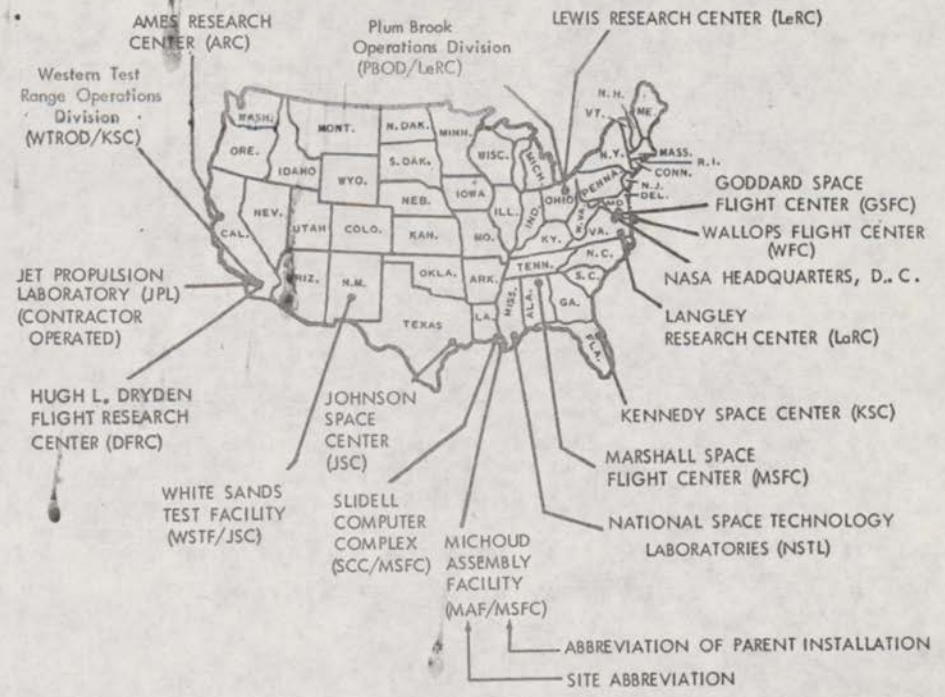
Cognizant Office	Budget Activity	Subfunction Code	Installation and Project	FY 1978	FY 1979	FY 1980	Page No.
				(In thousands of dollars)			
			Ames Research Center	---	9,770	2,900	
AST	5	402	Modification of Static Test Facility (N-249)....	---	---	2,900	CF 1-1
AST	5	402	Modification of the Unitary Plan Wind Tunnel (N-227).....	---	5,390	---	
AST	5	402	Modification of 3.5-Foot Wind Tunnel.....	---	1,870	---	
AST	5	402	Modification of 12-Foot Pressure Wind Tunnel....	---	2,510	---	
			Hugh L. Dryden Flight Research Center	420	---	1,500	
COMP	7	255	Construction of Large Aircraft Maintenance Dock.	---	---	1,500	CF 2-1
Mgmt Ops	5	402	Construction of Central Hydraulic System.....	420	---	---	
			Goddard Space Flight Center	4,500	5,640	---	
Mgmt Ops	7	255	Modifications and Additions for Logistic and Supply Functions.....	---	5,640	---	
S&TA	3	254	Construction of Additional Technical Processing Facilities.....	3,100	---	---	
ST&DS	7	255	Construction of an Addition to Building 14 for a Network Operations Control Center.....	1,400	---	---	
			Jet Propulsion Laboratory	2,830	4,630	---	
Mgmt Ops	7	255	Modifications to Various Buildings for Seismic Protection.....	2,830	1,570	---	
COMP	7	255	Modification to Space Flight Operations Facility.....	---	3,060	---	

Cognizant Office	Budget Activity	Subfunction Code	Installation and Project	FY 1978	FY 1979	FY 1980	Page No.
				(In thousands of dollars)			
			Lyndon B. Johnson Space Center	2,540	---	1,760	
COMP	7	255	Rehabilitation and Modification of Flight Operations Facilities, Ellington AFB.....	---	---	1,760	CF 3-1
Mgmt Ops	7	255	Modification of Chillers in Central Heating and Cooling Plant.....	2,540	---	---	
			John F. Kennedy Space Center	2,130	---	2,210	
COMP	7	255	Modifications to the Central Instrumentation Facility.....	---	---	1,260	CF 4-1
COMP	7	255	Modifications to the Operations and Checkout Building.....	---	---	950	CF 4-11
Mgmt Ops	7	255	Modifications for Utility Control System.....	2,130	---	---	
			Langley Research Center	1,770	6,500	7,980	
AST	5	402	Modifications of Model Support System 8-Foot High Temperature Structures Tunnel (1265).....	---	---	1,410	CF 5-1
AST	5	402	Modifications to 8-Foot Transonic Pressure Tunnel (640).....	---	---	2,000	CF 5-8
AST	5	402	Modification of Transonic Dynamics Tunnel (648).	---	---	970	CF 5-16
AST	5	402	Rehabilitation and Modification of Gas Dynamics Laboratory (1247).....	---	---	3,600	CF 5-22
Mgmt Ops	7	255	Modifications for Utility Control System.....	---	1,980	---	
AST	5	402	Rehabilitation of Unitary Plan Wind Tunnel.....	980	4,520	---	
Mgmt Ops	7	255	Rehabilitation of Main Heating Plant.....	790	---	---	
			Lewis Research Center	860	6,140	5,720	
AST	5	402	Modifications to Central Air System, Various Buildings.....	---	---	5,720	CF 6-1
AST	5	402	Construction of Research Analysis Center.....	---	6,140	---	
Mgmt Ops	7	255	Modification of Central Chilled Water System....	860	---	---	

Cognizant Office	Budget Activity	Subfunction Code	Installation and Project	FY 1978	FY 1979	FY 1980	Page No.
				(In thousands of dollars)			
			George C. Marshall Space Flight Center	---	---	3,540	
COMP	7	255	Modifications to Various Buildings	---	---	2,640	CF 7-1
COMP	7	255	Rehabilitation of Roofs, Various Buildings	---	---	900	CF 7-10
			National Space Technology Laboratories	620	---	---	
Mgmt Ops	7	255	Modifications for Utility Control System	620	---	---	
			Wallops Flight Center	---	---	1,100	
COMP	7	255	Construction of Facilities Operations Shop Building	---	---	1,100	CF 8-1
			Various Locations	1,750	---	---	
ST&DS	7	255	Rehabilitation and Modification of 64-Meter Antenna Components	1,750	---	---	
			Large Aeronautical Facilities at Various Locations as Follows:	37,000	56,100	45,900	
AST	5	402	Construction of National Transonic Facility (LaRC)	23,500	24,500	12,000	CF 9-1
AST	5	402	Modification of 40- by 80-Foot Subsonic Wind Tunnel (ARC)	13,500	31,600	33,900	CF 9-21
			Space Shuttle Facilities at Various Locations as Follows:	64,880	31,070	31,450	
STS	1	253	Modifications to Launch Complex 39 (KSC)	40,700	13,570	17,700	CF 10-4
STS	1	253	Modifications to Crawler Transporter Maintenance Facility (KSC)	---	---	1,250	CF 10-16
STS	1	253	Modification of Manufacturing and Final Assembly Facilities for External Tanks (MAF)	18,610	13,980	10,000	CF 10-24
STS	1	253	Minor Shuttle-Unique Projects (Various Locations)	1,750	1,600	2,500	CF 10-40

Cognizant Office	Budget Activity	Subfunction Code	Installation and Project	FY 1978	FY 1979	FY 1980	Page No.
				(In thousands of dollars)			
			Space Shuttle Facilities at Various Locations as Follows: (Cont'd)				
STS	1	253	Modifications to Solid Rocket Motor Manufacturing and Assembly Facilities, Thiokol Plant, Wasatch, Utah	---	1,920	---	
STS	1	253	Modifications to SRB Processing Facilities (KSC)	1,730	---	---	
STS	1	253	Rehabilitation of Barge Channels (KSC)	2,090	---	---	
			Space Shuttle Payloads Facilities at Various Locations as Follows:	6,410	---	4,250	
SS	2	254	Rehabilitation and Modification for Payload Ground Support Operations (KSC)	---	---	2,610	CF 11-1
SS	2	254	Modification of and Addition to Materials Sciences Laboratory (N240) (ARC)	---	---	1,640	CF 11-13
STS	2	254	Modifications and Addition for Shuttle Payload Vertical Processing (KSC)	6,410	---	---	
COMP	7	255	Repair of Facilities at Various Locations, Not in Excess of $500,000 per Project	---	---	12,000	CF 12-1
COMP	7	255	Rehabilitation and Modification of Facilities at Various Locations, Not in Excess of $500,000 per Project	18,900	12,800	19,790	CF 13-1
COMP	7	255	Minor Construction of New Facilities and Additions to Existing Facilities at Various Locations, Not in Excess of $250,000 per Project	5,950	4,200	3,500	CF 14-1
COMP	7	255	Facility Planning and Design	11,780	10,650	14,000	CF 15-1
			TOTAL	162,340	147,500	157,600	

LOCATION OF NASA MAJOR AND COMPONENT INSTALLATIONS



SUM 10

RECORDED VALUE OF CAPITAL TYPE PROPERTY
IN-HOUSE AND CONTRACTOR-HELD
AS OF SEPTEMBER 30, 1978
(DOLLARS IN THOUSANDS)

Reporting Installation	Real Property					Equipment	Fixed Assets in Progress	Grand Total
	Land	Buildings	Other Structures and Facilities	Leasehold Improvements	Total			
Ames Research Center	$ 2,928	$ 208,900	$ 8,313	$ 1,583	$ 221,724	$ 136,331	$ 19,108	$ 377,163
ARC - Moffett Field, CA	2,928	208,900	8,313	-0-	220,141	133,595	19,108	372,844
Various Locations (a)	-0-	-0-	-0-	1,583	1,583	2,736	-0-	4,319
Dryden Flight Research Center	-0-	12,094	3,765	-0-	15,859	62,310	2,478	80,647
DFRC - Edwards AFB, CA	-0-	12,094	3,765	-0-	15,859	58,692	2,478	77,029
Various Locations (a)	-0-	-0-	-0-	-0-	-0-	3,618	-0-	3,618
Goddard Space Flight Center	1,675	101,115	57,840	91	160,721	521,134	19,234	701,089
GSFC - Greenbelt, MD	1,322	85,179	16,642	-0-	103,143	232,849	14,743	350,735
Tracking Stations (Networks)	353	15,935	41,133	91	57,512	262,399	4,511	324,422
Various Locations (a)	-0-	1	45	-0-	46	25,886	-0-	25,932
Jet Propulsion Laboratory	1,188	86,131	69,309	520	157,148	231,701	25,305	414,154
JPL - Pasadena, CA	1,188	76,087	10,581	520	88,376	149,326	25,305	263,007
Deep Space Network	-0-	10,044	58,728	-0-	68,772	82,375	-0-	151,147
Johnson Space Center	9,107	194,928	61,080	53	265,168	421,746	23,034	709,948
JSC - Houston, TX	5,537	159,390	35,059	-0-	199,986	336,712	17,413	554,111
White Sands Test Facility								
WSTF - Las Cruces, NM	-0-	9,456	20,945	-0-	30,401	22,350	-0-	52,751
Various Locations (a)	3,570	26,082	5,076	53	34,781	62,684	5,621	103,086
Kennedy Space Center	71,345	332,226	314,580	-0-	718,151	494,442	116,583	1,329,176
KSC - Cape Canaveral, FL	71,345	332,226	314,580	-0-	718,151	489,521	116,583	1,324,255
Western Test Range Operations Div.								
WTROD - Lompoc, CA	-0-	-0-	-0-	-0-	-0-	3,879	-0-	3,879
Various Locations (a)	-0-	-0-	-0-	-0-	-0-	1,042	-0-	1,042
Langley Research Center	162	144,442	189,847	-0-	334,451	163,301	11,317	509,069
LARC - Hampton, VA	156	130,042	189,771	-0-	319,969	148,035	11,317	479,321
Various Locations (a)	6	14,400	76	-0-	14,482	15,266	-0-	29,748
Lewis Research Center	3,651	213,729	76,819	136	294,335	120,441	12,948	429,724
LERC - Cleveland, OH	316	131,456	57,288	136	189,196	96,830	12,948	298,974
Plumbrook Operations Division								
PBOD - Sandusky, OH	3,335	82,273	19,531	-0-	107,139	11,628	-0-	118,767
Various Locations	-0-	-0-	-0-	-0-	-0-	11,983	-0-	11,983
Marshall Space Flight Center	7,137	199,564	105,543	-0-	311,946	686,106	8,016	1,006,068
MSFC - Huntsville, AL	-0-	123,791	62,871	-0-	186,662	553,834	8,016	748,503
Michoud Assembly Facility								
MAF - New Orleans, LA	7,072	66,355	29,108	-0-	102,535	28,272	-0-	130,807
Slidell Computer Complex								
SCC - Slidell, LA	65	4,973	2,027	-0-	7,065	13,052	-0-	20,117
Various Locations (a)	-0-	4,147	11,537	-0-	15,684	90,958	-0-	106,642
National Space Technology Labs.	18,061	64,204	194,077	-0-	276,342	30,919	-0-	307,261
NSTL - NSTL Station, MS	18,061	64,204	194,077	-0-	276,342	30,919	-0-	307,261
Wallops Flight Center	1,283	25,769	52,295	-0-	79,347	52,826	4,505	136,678
WFC - Wallops Island, VA	1,283	25,769	52,295	-0-	79,347	50,710	4,505	134,562
Various Locations (a)	-0-	-0-	-0-	-0-	-0-	2,116	-0-	2,116
NASA Headquarters	-0-	-0-	-0-	-0-	-0-	11,764	-0-	11,764
Washington, DC	-0-	-0-	-0-	-0-	-0-	3,727	-0-	3,727
Various Locations (a)	-0-	-0-	-0-	-0-	-0-	8,037	-0-	8,037
TOTAL	$ 116,537	$ 1,584,804	$1,112,468	$ 2,383	$ 2,837,192	$ 2,933,021	$ 242,328	$ 6,012,741

(a) Includes Property in Possession of Contractors at Various Locations.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

SUMMARY

AMES RESEARCH CENTER

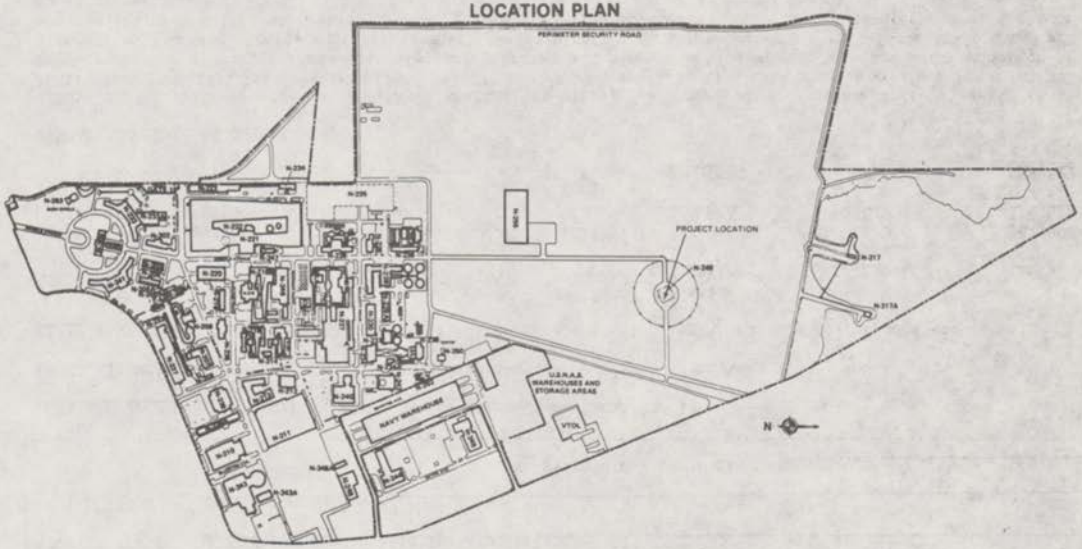
	Amount	Page No.
Office of Aeronautics and Space Technology:		
Modification of Static Test Facility.....	2,900,000	CF 1-1

AMES RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

MODIFICATION OF STATIC TEST FACILITY (N-249)

LOCATION PLAN



CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE: Modification of Static Test Facility (N-249)

INSTALLATION: Ames Research Center

FY 1980 CoF ESTIMATE: $2,900,000

LOCATION OF PROJECT: Moffett Field, Santa Clara County, California

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Technology

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	194,000	187,000	381,000
Capitalized investment	N/A	178,699	178,699
Total	194,000	365,699	559,699

SUMMARY PURPOSE AND SCOPE:

This project will provide unique static testing capability for rotorcraft and powered-lift aircraft at the Static Test Facility, Ames Research Center (ARC) (Figure 1). Specifically, this project will provide a variable frequency power system, a large capacity gantry crane, and a new mounting system to accommodate model or aircraft roll motion. These modifications will improve safety during model or aircraft installation, and will accommodate ground effects testing that will more closely simulate the conditions encountered during actual hover operations.

The Static Test Facility is a valuable and unique research facility for the testing and evaluation of Vertical Takeoff and Landing (VTOL) aircraft performance and for aero-propulsion noise research. In addition, significant wind tunnel occupancy time is otherwise not required by using the Static Test Facility for functionally checking out remote control operations, as well as research and safety monitoring instrumentation to ensure that the test vehicle hardware is operating correctly prior to wind tunnel installation. This facility will provide a valuable asset as increasing numbers of rotorcraft and powered-lift aircraft are tested in support of both civil and military programs.

PROJECT JUSTIFICATION:

Rotor whirl testing at the Static Test Facility is presently restricted to turbine driven models. Many current and near future models of advanced rotor systems require electronic motor drive for whirl testing. The proposed project will provide electric power suitable for driving an existing Rotor Test Apparatus which is required for testing advanced rotor systems. The alternatives to performing these whirl tests at the Static Test Facility would be to use the test section of the 40x80-Foot Wind Tunnel. This alternative has several severe disadvantages which include the tying up of a valuable test facility for work better suited to a static test facility, the introduction of wind tunnel wall effects on the aerodynamic flow fields being investigated, and the acoustic interference related to the wind tunnel structure. An even more important consideration is that of safety. With new untested rotor systems, there is the possibility of catastrophic failure occurring during the initial whirl testing which could result in destruction of valuable test equipment and model, as well as extensive damage to the wind tunnel itself.

The Static Test Facility is unique with regard to its capability for testing VTOL aircraft. The present method of installing a model is for a boom crane to swing the model into place over the model support system. The crane access is limited to the outside of the scale pit so that considerable boom extension is required. This severely limits the weight of models that can be safely installed at the facility. For heavier models, installation is hazardous both to equipment and the installing personnel. A gantry crane, with a structure that straddles the test pad and that runs on rails, will allow efficient, safe installation of the model. The gantry will be sized to accept models for the 80x120-Foot Wind Tunnel test section.

The present model support system (Figure 2) at the Static Test Facility does not easily permit roll variation with models, and the force measuring system accuracy with roll is questionable. Since roll profoundly affects hover characteristics on VTOL aircraft, it is essential that a system be developed to vary roll angle easily and provide the capability of making measurements with confidence. An easily adjustable strut tip and a load cell design that will correctly measure three components with a side force preload will be developed.

IMPACT OF DELAY:

No other suitable facility exists to perform the necessary test and check-out of VTOL aircraft prior to installation of the model in either 40x80-Foot or 80x120-Foot Wind Tunnels. This is required because of the possibility of the rotor systems failing and causing damage to personnel and equipment. Delay of this project could impact existing and future programs.

PROJECT DESCRIPTION:

This project will provide a variable frequency power system consisting of a motor generator set similar to the existing system now used in the 40x80-Foot Wind Tunnel. It will be capable of providing the power and speed control to drive the existing electric motors of the Rotor Test Apparatus at power values up to 3,000 horsepower (2.2 megawatts). A pre-engineered enclosed metal building of approximately 2,000 square feet (186 square meters) will be provided to shelter the motor generator set. This building will be located west of Building N-236 on 7th Street.

The gantry crane to be provided by this project will be sized to accept models which will be tested in the 80x120-Foot Wind Tunnel. The gantry will be self-propelled and contain its own power source for the crane operation. It will be designed to maximum loads of 75 tons (68,025 kilograms) download, 30 tons (266,880 newtons) upload, 15 tons (133,440 newtons) sideload, and 30 tons (266,880 newtons) in the thrust or drag directions. Approximately 100 linear feet (30.5 meters) of track will be included to load and unload models and to store the gantry during strut-mounted model tests.

The new mounting provisions (Figure 3) for roll motion capability include two hydraulic jack screws mounted on top of the main struts with three component load cells and socket attachments for the models. Each jack screw and load cell will be designed for 35,000 pounds (155,680 newtons) vertical compression, 15,000 pounds (66,720 newtons) vertical tensions, 4,000 pounds (17,792 newtons) sideload, and 8,000 pounds (35,580 newtons) thrust or drag loading and linear motion of 6 feet (1.8 meters). Controls for the jack would be located in an existing underground control room. Hydraulic power units for the screwjacks also will be included in the project.

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PROJECT COST ESTIMATE:

The cost estimate for this project is based on a completed Preliminary Engineering Report.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	2,900,000
Variable frequency power supply	LS	---	---	1,692,000
Transformer/motor generator set	LS	---	---	(1,125,000)
Duct bank	LS	---	---	(567,000)
Gantry crane	LS	---	---	66,000
Mounting system	LS	---	---	1,042,000
Metal building	SF	2,000	35.00	70,000
Site work and utilities	LS	---	---	30,000
Fallout Shelter (not feasible)	---	---	---	---
Total				2,900,000

5271

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Site Plan
Figure 3 - Schematic of Facility

OTHER EQUIPMENT SUMMARY:

None

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

There are no future requirements to complete this project.

AMES RESEARCH FACILITY

FISCAL YEAR 1980 ESTIMATES

MODIFICATION OF STATIC TEST FACILITY (N-249)

SITE PLAN



Figure 2

AMES RESEARCH CENTER

FISCAL YEAR 1980

MODIFICATION OF STATIC TEST FACILITY (N-249)

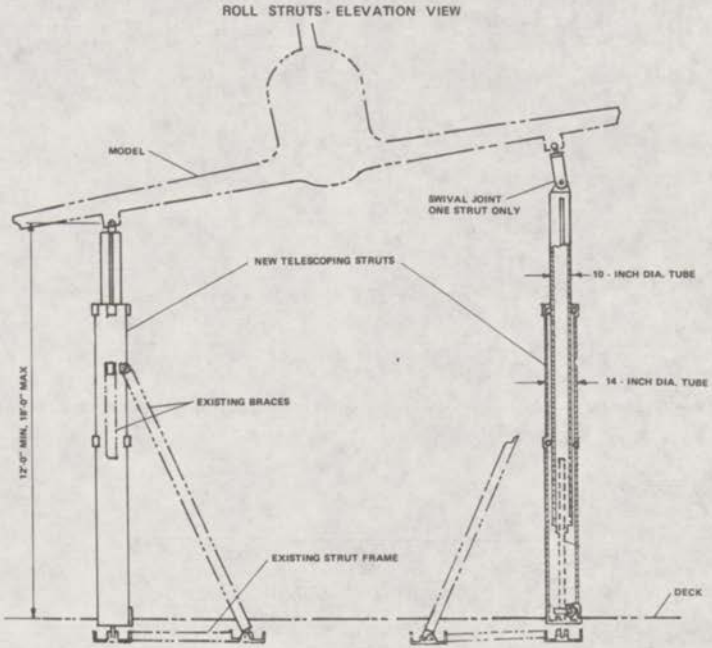


Figure 3

CF 1-7

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

SUMMARY

HUGH L. DRYDEN FLIGHT RESEARCH CENTER

	Amount	Page No.
Office of the Comptroller:		
Construction of Large Aircraft Maintenance Dock.....	1,500,000	CF 2-1

HUGH L. DRYDEN FLIGHT RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

CONSTRUCTION OF LARGE AIRCRAFT MAINTENANCE DOCK

LOCATION PLAN

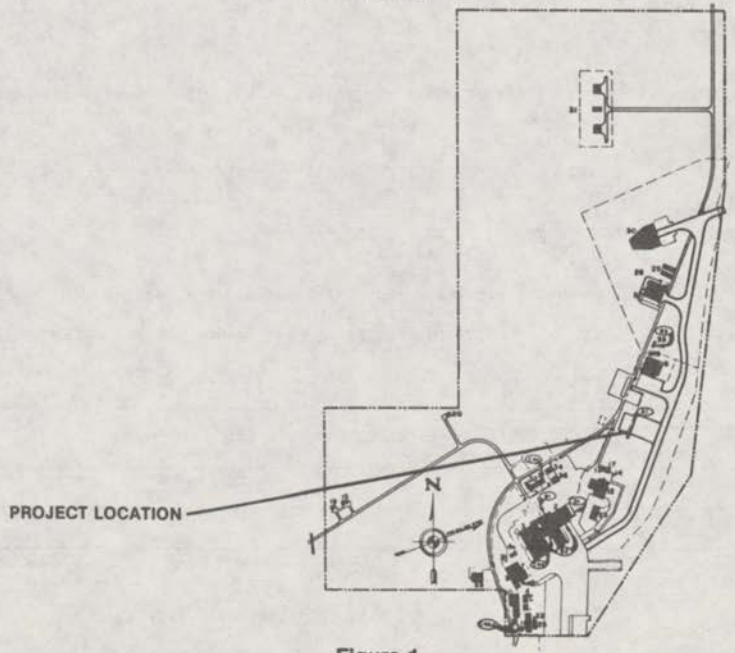


Figure 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE: Construction of Large Aircraft Maintenance Dock

INSTALLATION: Hugh L. Dryden Flight Research Center

FY 1980 CoF ESTIMATE: $1,500,000

LOCATION OF PROJECT: Edwards, Kern County, California

COGNIZANT HEADQUARTERS OFFICE: Office of the Comptroller, Facilities Division

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	80,000	---	80,000
Capitalized investment	N/A	*---	*---
Total	80,000	---	80,000

*Assessment based on todays market value indicates an equivalent worth of $1,800,000 to $2,100,000 associated with Air Force dock to be relocated.

SUMMARY PURPOSE AND SCOPE:

The installation of a large USAF surplus aircraft maintenance dock at the Dryden Flight Research Center (DFRC) is required to provide protection from temperature extremes, sand and dust to personnel and equipment involved in preflight, postflight, maintenance, and ground test operations. The aircraft maintenance dock

will be used to house and protect such large aircraft as the B-52 carrier aircraft, the YC-14 and YC-15 Advanced Medium STOL Transports and other aircraft.

The facility will provide an effective means to perform preflight preparations, aircraft maintenance, research instrumentation systems checkout, postflight operations, and other ground support activity, with an enclosed service area large enough to cover the forward fuselage and wing portion of large aircraft. For example, the structure is 241 feet (74 meters) wide with clear door opening of approximately 200 feet (61 meters) in width and 28 feet, six inches (8.7 meters) in height. This building is 28 feet (8.5 meters) deep and has provisions and space for an aircraft service area, restrooms, mechanical equipment, storage, and ground support equipment.

PROJECT JUSTIFICATION:

A hangar facility for large aircraft has been a basic requirement at DFRC for several years. Even with carefully planned procedures to limit mated ground operations, programs supported by B-52 carrier aircraft encountered serious conditions associated with weather such as summer and autumn temperatures that regularly exceed 100° Fahrenheit (38° Centigrade) resulting in aircraft skin surfaces becoming so hot that aircraft crews could not work effectively and, by contrast, winter season temperatures that drop to subfreezing levels. In addition, desert windstorms also seriously infringe upon outdoor aircraft maintenance and flight preparation work.

Within the past two years, the Center has moved intensively into a Remotely Piloted Research Vehicles (RPRV) mission. The utilization of these RPRV has introduced the application of prototype and costly electronic systems and ground support and checkout system. It is essential to assure that these systems are completely functional in a mated configuration. It is not safe or technologically acceptable to work these systems in the open, without shelter from adverse weather conditions.

Current RPRV programs within flight operations planned through FY 1983 include the F-15 Spin Research Vehicle (SRV), Firebee/DAST (Drones for Aerodynamic Structural Testing) and the HIMAT research vehicles (Highly Maneuverable Aircraft Technology). The lack of a large aircraft hangar facility at DFRC has an adverse impact on these programs.

In addition to RPRV programs that involve the B-52 carrier aircraft, the Center also has other aircraft flight research activities that require large aircraft hangar facilities. They include Advanced Medium STOL Transport investigations involving the flight operations of YC-14 and YC-15 aircraft and recurring wake vortex flight investigations that involve several large aircraft such as the DC-10 and L-1011 with research flight test operations planned test operations through FY-1983. In each of these programs the availability of a large hangar will significantly improve scheduling and performance, and avoid costly delays that will occur if there

are no adequate facilities in which to perform instrumentation systems checkouts, aircraft maintenance and pre- and post- flight operations. The Center has no facility of sufficient size to accommodate a large aircraft. The Shuttle Hangar was sized specifically to accommodate the Space Shuttle. Consequently, the width of the Shuttle Hangar Door is only 137 feet (42 meters) and cannot house aircraft with large wing spans (for example, the B-52 has a wing span of 185 feet (56 meters)). More significantly, the Shuttle Hangar is heavily committed to the Shuttle Orbital Flight Test (OFT) Program. Additionally, DFRC has been designated as the secondary recovery site. This will require that the Space Shuttle facilities at DFRC be in a complete state of readiness for recovery and post-recovery operation for each Space Shuttle flight.

In summary, the need for a large aircraft maintenance dock is geared at present to existing Remotely Piloted Research Vehicle programs requiring the B-52 carrier aircraft. The installation of a large aircraft facility now will significantly enhance the Center's capability in scheduling and flight turn-around by avoiding the interruptions and problems of attempting to perform ground support operations out-of-doors. The costs in lost time due to outdoor ground support operations, or even more significant costs that would occur due to requirements for off-site maintenance repair and other ground support activities, can be avoided if the surplus Air Force maintenance dock is relocated. This proposed facility is in complete harmony with the Center's facility master planning and the facility environmental analyses.

IMPACT OF DELAY:

The delay in acquisition of this facility will result in a continuance of the present maintenance mode and mating of research vehicles with their inherent limitations and risks. The current availability of a surplus Air Force maintenance dock will provide a cost effective solution to a long standing Center need for a protective envelope for large aircraft.

PROJECT DESCRIPTION:

This project involves the dismantling, moving and re-erection of a surplus Air Force maintenance dock. The dock is presently located at Glasgow Air Force Base, Montana, and is planned for use at the Dryden Flight Research Center, Edwards, California. The facility will be located immediately adjacent to the Center's existing taxiway (Figures 1 and 2). The facility will be re-erected on a concrete hangar floor of 10-inch (25.4 centimeters) reinforced concrete with a full width 16-inch (40.6 centimeters) reinforced concrete apron connecting with the existing taxiway.

The dock is a steel structure, 241 feet (74 meters) wide at the front, with a clear door opening of approximately 200 feet (61 meters) in width and 28 feet, six inches (9.7 meters) in height and provides a gross area of approximately 27,000 square feet (2,508 square meters) (Figure 3). It is equipped with manually operated

sliding hangar doors at the front of the structure and overhead vehicle and equipment doors on each of the two sides of the building. The roofing and siding are corrugated sheet metal and will be insulated. The dock has two existing 7,000 pound (3,175 kilogram) capacity bridge cranes with all necessary structural supports. New toilet facilities, hot water heating, electrical and lighting and fire protection systems will be provided.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	1,500,000
Site preparation	LS	---	---	290,000
Utilities (outside 5-foot line)	LS	---	---	120,000
Dismantling/shipping, and site restoration	LS	---	---	300,000
Architectural/structural	SF	27,000	19.45	525,000
Mechanical	SF	27,000	7.95	215,000
Electrical	SF	27,000	1.85	50,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				1,500,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Site Plan
Figure 3 - Building Floor Plan

OTHER EQUIPMENT SUMMARY:

No other collateral or non-collateral equipment is involved.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

There are no currently foreseen future funding requirements to complete this project.

HUGH L. DRYDEN FLIGHT RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

CONSTRUCTION OF LARGE AIRCRAFT MAINTENANCE DOCK

SITE PLAN

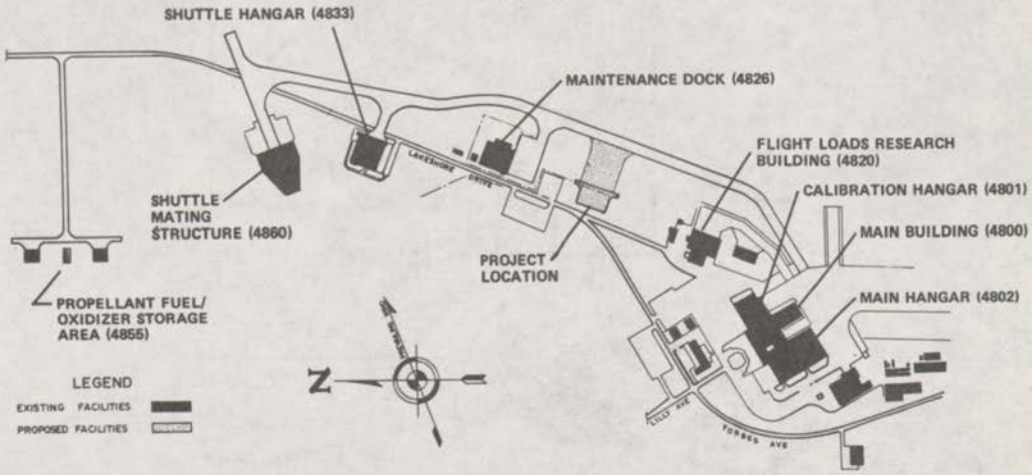


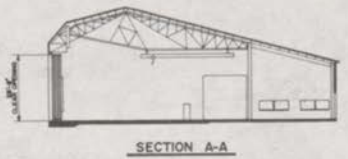
Figure 2

HUGH L. DRYDEN FLIGHT RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

CONSTRUCTION OF LARGE AIRCRAFT MAINTENANCE DOCK

FLOOR PLAN





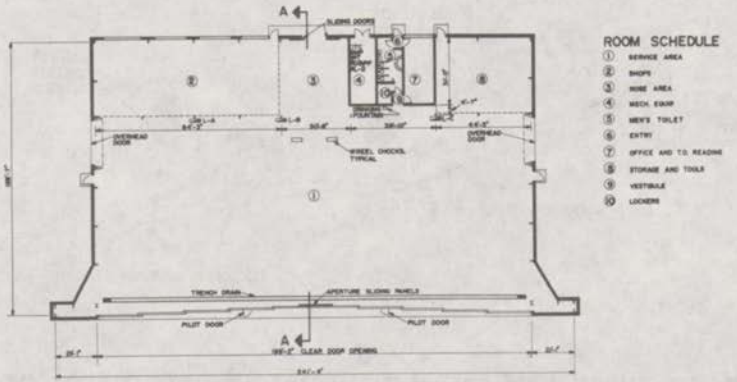


Figure 3

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

SUMMARY

LYNDON B. JOHNSON SPACE CENTER

	Amount	Page No.
Office of the Comptroller:		
Rehabilitation and Modification of Flight Operations Facilities, Ellington Air Force Base.....	1,760,000	CF 3-1

LYNDON B. JOHNSON SPACE CENTER
FISCAL YEAR 1980 ESTIMATES
REHABILITATION AND MODIFICATION OF FLIGHT OPERATIONS FACILITIES
ELLINGTON AIR FORCE BASE

LOCATION PLAN

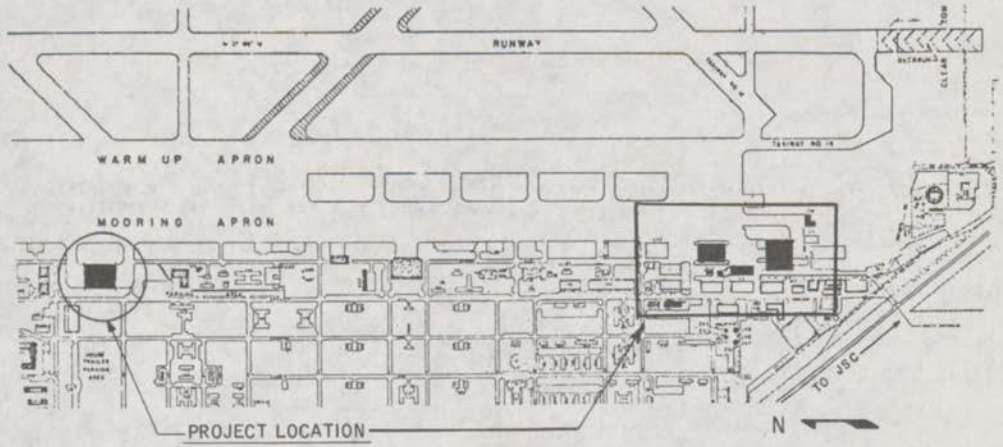


FIGURE 1

CF 3-1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE: Rehabilitation and Modification of Flight Operations Facilities, Ellington Air Force Base

INSTALLATION: Lyndon B. Johnson Space Center

FY 1980 CoF ESTIMATE: $1,760,000

LOCATION OF PROJECT: Houston, Harris County, Texas

COGNIZANT HEADQUARTERS OFFICE: Office of the Comptroller, Facilities Division

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	200,000	585,000	785,000
Captalized investment	N/A	*1,994,000	1,994,000
Total	200,000	2,579,000	2,779,000

*NASA-owned facilities and facilities occupied by NASA under permit from Air Force.

SUMMARY PURPOSE AND SCOPE:

This project provides for completion of required rehabilitation and modification of NASA's flight operations facilities that support Shuttle and Earth Resources aircraft programs at Ellington Air Force Base (EAFB). These facilities were originally constructed over 24 years ago and have been in continuous use since that time. In recent years, because of the uncertain future of the facilities, only minimum maintenance has been performed to keep the facilities operational. Consequently, the general condition of facilities, especially Hangar 990,

is poor. Most are in immediate need of rehabilitation, and this work is required in the FY 1980 time frame. This project consists of the general rehabilitation and modification of Hangar 990 which is to include providing a fire protection system, replacement of roofing and air-conditioning units, general painting, motorizing large hangar doors, and adding electrical power, air-conditioning in laboratories and shops, and other related work. The project also includes rehabilitation of 2 other hangars and 5 buildings as well as the completion of repairs to aircraft parking aprons. Work in the other hangars and buildings include rehabilitation of heating, ventilating, and air-conditioning systems and replacement of roofing. This project is needed to maintain the integrity of the facilities and to place them in a safe, reliable, and usable condition for aircraft operations, as well as to protect the Government's investment in the facilities.

PROJECT JUSTIFICATION:

These World War II mobilization-type facilities house aircraft flight operations and maintenance activities. They are utilized to support the Space Shuttle and Earth Resources Programs, as well as other activities essential to the mission of Johnson Space Center. These are the only available airfield facilities within 200 miles (322 kilometers) of the Center capable of providing this support. Hangar 990 was constructed in 1954, and the other NASA flight operations buildings were constructed as World War II mobilization facilities in 1942. These facilities have been in continuous use since that time. Due to the uncertain future of these facilities, since the Air Force decided in 1976 to vacate the installation, only minimum maintenance has been performed. This project is necessary to rehabilitate these facilities so they may be completely functional and usable and can be maintained in a routine manner. It is also necessary to modify the facilities to meet acceptable standards in areas of safety and fire protection. The facilities are required to accommodate research and training aircraft which provide critical support to the Space Shuttle and Earth Resources programs.

NASA began to use Hangar 990 in 1976. Since that time, NASA has performed only minimum maintenance of the facility to keep it operational. General rehabilitation of the hangar will bring it up to minimum standards for its current utilization as an aircraft operations and maintenance hangar for the Earth Resources Program. The facility houses three WB-57F's, a NC-130B and a KC-135 aircraft as well as two helicopters, which are maintained by 20 civil service and 20 contractor personnel. Also located in this hangar are an aircraft pressure suit laboratory, a pallet laboratory, nondestructive inspection equipment and instrumentation. These aircraft are associated with the Airborne Instrumentation Research, the Atmospheric Research, and the Reduced Gravity Flight Test Programs. The aircraft and their associated instrumentation pallets are valued at approximately $40,000,000. Hangar 990 is a single story facility with a two-story lean-to and adjacent concrete mooring apron and access pavement. The total value of this facility is approximately $6 million.

The remaining flight operations facilities were occupied by NASA in 1962. Shuttle training aircraft, administrative aircraft, and astronaut flight proficiency aircraft are operated and maintained from these

hangars. Buildings 136, 239, 270, 271, and 272 house various activities associated with all NASA flight operations and maintenance activities at the Base. Most of these facilities contain costly, delicate equipment and instrumentation. A project in NASA's FY 1979 budget provided for the most urgent rehabilitation work required in these and other facilities at EAFB. This project will complete that rehabilitation effort. The aircraft operated and maintained from these facilities are valued at $50,000,000, and associated spare parts are valued at $4,500,000. The estimated replacement value of the hangars and support buildings is approximately $5,000,000, not including the aircraft parking aprons. The rehabilitation of aircraft parking aprons is necessary since they have cracked and settled in many places due to failure of the base material. Spalling of the apron concrete where cracks have occurred and movement of aircraft across these areas are factors which result in excessive wear and costly maintenance on the aircraft.

IMPACT OF DELAY:

In general, rehabilitation of these facilities is required because of age (obsolete equipment) and past austere maintenance efforts. It is now essential that rehabilitation be accomplished to maintain the integrity of the facilities and place them in a safe, reliable, usable condition for aircraft operations and to protect the Government's investment in the facilities. Failure to implement this project will result in further deterioration of facilities and equipment, less reliability and safety in operations, and increased future costs for maintenance and operations, as well as for any subsequent rehabilitation and modification.

PROJECT DESCRIPTION:

This project provides for the rehabilitation of aircraft maintenance Hangars 990, 135, and 276 and support Buildings 136, 239, 270, 271, and 272 located at EAFB. The general rehabilitation and modification of Hangar 990 includes installing automatic high expansion foam and manual aqueous film-forming, foam dispensing, fire protection systems in the area; replacing approximately 51,100 square feet (4,747 square meters) of built-up roofing over the high bay and office areas; replacing two air-conditioning units, one 20-ton and one 25-ton, including ducts and controls; replacing substandard interior walls, ceilings, and doors; adding fire doors and panic hardware, electrical service and lighting, and air-conditioning ducts and controls to first floor laboratories and shops; repainting the interior and exterior of the hangar; resealing joints in the concrete apron and access pavement adjacent to the hangar; and motorizing the existing large rolling doors located on the north and south ends of the hangar.

Also included in the project is the rehabilitation of heating, ventilating, and air-conditioning systems of Buildings 135, 136, 239, 270, 271, 272, and 276. This includes the repair of air handler casings and structures, valves, pumps, fan and scroll assemblies, dampers, and ducts; cleaning coils; replacing pipe suspension; calibrating instrumentation; and insulating and painting all components and ancillary equipment. The work

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includes the replacement of 20 direct expansion air-conditioning units ranging in size from 1.5 tons to 25 tons. Also included is the replacement of the supply and exhaust ventilation units with modifications to the ventilation plenums and controls for the Corrosion Control Facility, Building 136. In addition, the project includes the replacement of approximately 12,000 square feet (1,115 square meters) of built-up roofing on portions of Hangars 135 and 276. The rehabilitation of aircraft parking aprons consists of replacing approximately 1,200 square feet (111 square meters) of concrete slab, including base material and tie-down anchors.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	1,760,000
Hangar 990	---	---	---	1,460,000
Repair aprons and access drive	LS	---	---	(27,400)
Replace roofing	SF	51,100	3.74	(191,100)
Painting (interior and exterior)	SF	80,000	0.60	(48,000)
Install motorized hangar doors	EA	4	34,400.00	(137,600)
Install fire protection systems	LS	---	---	(527,400)
Mechanical and plumbing	LS	---	---	(177,600)
Electrical	LS	---	---	(252,500)
Architectural and structural	LS	---	---	(98,400)
Hangar 135	---	---	---	42,000
Repair roofing	SF	5,000	312.00	(15,600)
Replace air-conditioning				
7.5 ton units	EA	6	4,400.00	(26,400)
Hangar 276	---	---	---	36,300
Repair roofing	SF	7,000	312.00	(21,800)
Replace air-conditioning				
7.5 ton units	EA	2	4,400.00	(8,800)
1.5 ton units	EA	3	1,900.00	(5,700)

	Unit of Measure	Quantity	Unit Cost	Cost
Building 136, air-conditioning	LS	---	---	87,000
Building 239, air-conditioning	LS	---	---	28,400
Buildings 270, 271, 272				
Replace air-conditioning, 1.5 ton units	EA	3	1,900.00	5,700
Repair aprons	SF	1,200	83.80	100,600
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				1,760,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Photograph of Hangar 990 w/B57 inside
Figure 3 - Photograph of Interior, Hangar 990
Figure 4 - Photograph of Roof, Hangar 990

OTHER EQUIPMENT SUMMARY:

No other equipment is required.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

There may be a requirement for some storm sewer and drainage work in the future. Total scope and cost are presently unknown.

LYNDON B. JOHNSON SPACE CENTER
FISCAL YEAR 1980 ESTIMATES
REHABILITATION & MODIFICATION OF FLIGHT OPERATIONS FACILITIES.
ELLINGTON AIR FORCE BASE

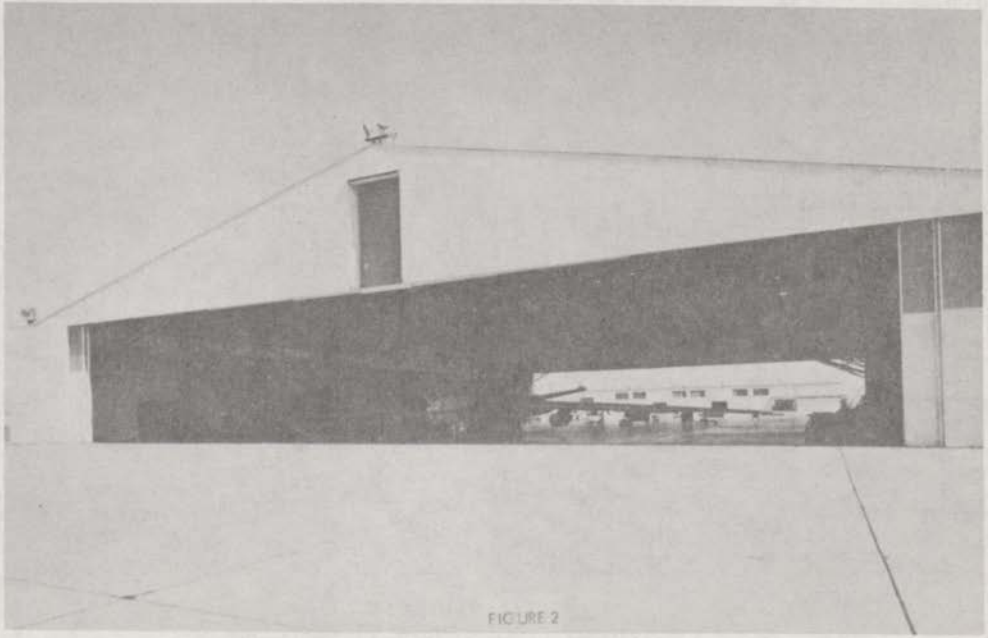


FIGURE 2

CF 3-8

LYNDON B. JOHNSON SPACE CENTER
FISCAL YEAR 1980 ESTIMATES

REHABILITATION & MODIFICATION OF FLIGHT OPERATIONS FACILITIES,
ELLINGTON AIR FORCE BASE



FIGURE 3

LYNDON B. JOHNSON SPACE CENTER
FISCAL YEAR 1980 ESTIMATES
REHABILITATION & MODIFICATION OF FLIGHT OPERATIONS FACILITIES.
ELLINGTON AIR FORCE BASE

CF 3-10



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

SUMMARY

JOHN F. KENNEDY SPACE CENTER

	Amount	Page No.
Office of the Comptroller:		
Modifications to the Central Instrumentation Facility	1,260,000	CF 4-1
Modifications to the Operations and Checkout Building	950,000	CF 4-11
Total	2,210,000	

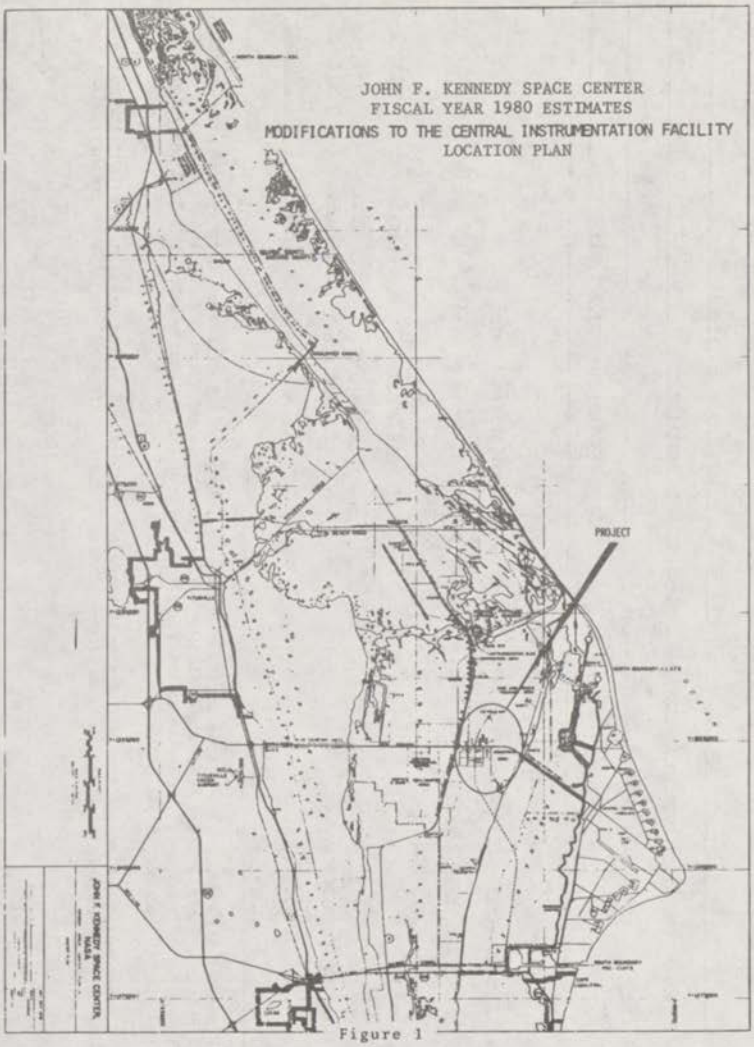

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1980 ESTIMATES
MODIFICATIONS TO THE CENTRAL INSTRUMENTATION FACILITY
LOCATION PLAN
PROJECT

Figure 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE: Modifications to the Central Instrumentation Facility

INSTALLATION: John F. Kennedy Space Center

FY 1980 CoF ESTIMATE: $1,260,000

LOCATION OF PROJECT: Merritt Island, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of the Comptroller, Facilities Division

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	143,000	---	143,000
Capitalized investment	N/A	7,917,655	7,917,655
Total	143,000	7,917,655	8,060,655

SUMMARY PURPOSE AND SCOPE:

This project will provide for a substantial reduction in energy and associated costs by reducing the capacity of the heating, ventilating and air-conditioning (HVAC) system and refixturing the lighting system to support the Space Shuttle Transportation System at the 136,378 square foot (12,670 square meters) Central Instrumentation Facility (CIF), Building M6-342.

The planned modifications to the HVAC system include the replacement of the existing air handling units on the roof which serve both overhead and underfloor systems. The new air handlers will be properly sized and

those to be installed on the roof will support the overhead systems, while the new bottom discharge floor-mounted units will be installed within the building to meet each computer room's underfloor cooling requirements. The lighting modifications will consist of replacing approximately 2,680 300-watt incandescent fixtures with more energy efficient fluorescent fixtures.

The present HVAC systems were designed with larger than presently necessary capacities to maintain low humidity levels and for flexibility to support computer use. They were operated during the Apollo program 24 hours a day, 7 days a week. The existing HVAC equipment is old and requires constant maintenance and should now be replaced. Additionally, this equipment is not energy efficient. The new units will significantly increase the reliability of operation. Also, replacing these air-handler units with smaller capacity units will simplify control and maintenance and conserve energy. The incandescent lighting fixtures were originally necessary to provide a radio frequency-free environment for instrumentation and equipment in the facility. Now, radio frequency-free fluorescent fixtures are available which consume less energy, improve lighting, and create less heat, and the present equipment and instrumentation in this facility is less sensitive to radio frequency emanations.

PROJECT JUSTIFICATION:

The CIF is the prime control and instrumentation center for the Space Shuttle and Expendable Vehicles space missions. The facility houses computers for space missions and automatic data processing for administrative purposes. These computers are sensitive to temperature and humidity and, therefore, must operate in a controlled environment, but current equipment and related environmental requirements have reduced the once very stringent earlier requirement.

As previously described, the HVAC system was originally over-designed by intent. With energy now critical in terms of cost and availability, this unnecessary added capability is an unwanted burden. In addition, the conversion of incandescent lighting to fluorescent will greatly reduce the heat load. As a result, the necessary capacity of the cooling system can be reduced by some 89×10^9 Btu per year and still meet the HVAC needs in this facility. Regardless of the energy conservation requirements, replacement of many components of the HVAC system would be necessary, in any event, to keep the system operating. This is especially true of such elements as exterior piping insulation, coil manifolds, and valves.

The replacement of the incandescent fixtures by fluorescent fixtures will result in a savings of some 23×10^9 Btu per year due to the reduced energy required per lumen. In addition, this will result in a reduction of light levels in certain areas, and also reduces the heat load on the HVAC system. The installation of discriminatory controls has the future advantage of resulting in an annual manpower savings of 2 man-years through the elimination of manual control.

IMPACT OF DELAY:

Implementation of this project will produce energy savings of 9,500,000 kWh/yr of electricity, and 11,000 gallons of oil per year, yielding a total energy savings of 112×10^9 Btu per year, and a reduction of 2 man-years in manpower. These reductions will result in a payback period of less than 3 years. Failure to implement this project will not allow this cost savings to be realized and, as pointed out, the existing system requires extensive, continual maintenance.

PROJECT DESCRIPTION:

This project provides for the modifications and replacement of major components of the HVAC system in the CIF. The work will involve removing the existing air handlers, plenums, ductwork, chilled and hot water piping, motors, starters and disconnects. It will also involve removing all of the existing recessed incandescent lighting fixtures and replacing them with fluorescent fixtures on all three floors. Six new air handlers, filters, economizer assemblies, and return air blowers, including all ductwork, piping, motors, and controls for the building overhead system will be installed on the roof. Twenty-four floor mounted air handlers including all ductwork, piping motors and controls will be installed in all three floors for the equipment underfloor system. The existing Utility Control System data sensors will be relocated to the new systems. The existing variable air volume induction terminal units will be rebalanced. The room thermostats will be adjusted and new high-capacity air filters will be installed. New surface mounted 2- or 4-lamp (as required) fluorescent fixtures will be installed in the ceiling grid and electricity connected to the existing incandescent light circuits.

PROJECT COST ESTIMATE:

The bases of this cost estimate are Preliminary Engineering Reports and related studies.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	1,260,000
Demolition and rework HVAC	LS	---	---	59,000
Overhead HVAC system	LS	---	---	384,000
Underfloor HVAC system	LS	---	---	440,000
Demolition and repair electrical system	LS	---	---	132,000
Lighting fixtures	EA	2,680	89.93	241,000
UCS data sensors	LS	---	---	4,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				1,260,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Site Plan
Figure 3 - Typical Floor Plan
Figure 4 - HVAC Schematics
Figure 5 - Central Instrumentation Facility Lighting

OTHER EQUIPMENT SUMMARY:

There is no other equipment required to be used with this facility project.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

There is no future estimated funding required for this facility project.

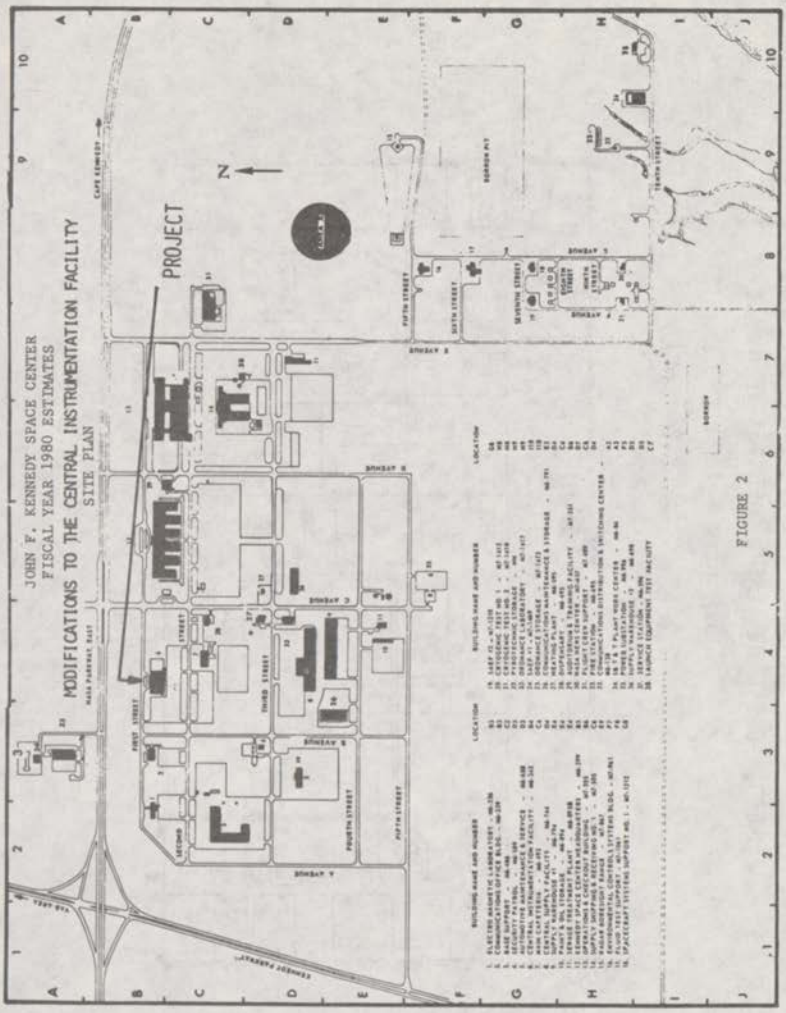


FIGURE 2

CF 4-7

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1980 ESTIMATES

MODIFICATIONS TO THE CENTRAL INSTRUMENTATION FACILITY

TYPICAL FLOOR PLAN

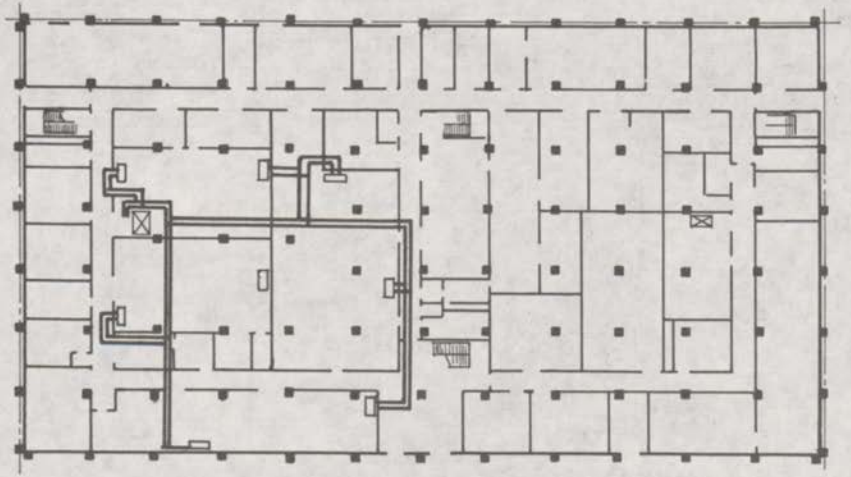


FIGURE 3

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1980 ESTIMATES

MODIFICATIONS TO THE CENTRAL INSTRUMENTATION FACILITY

HVAC SCHEMATICS

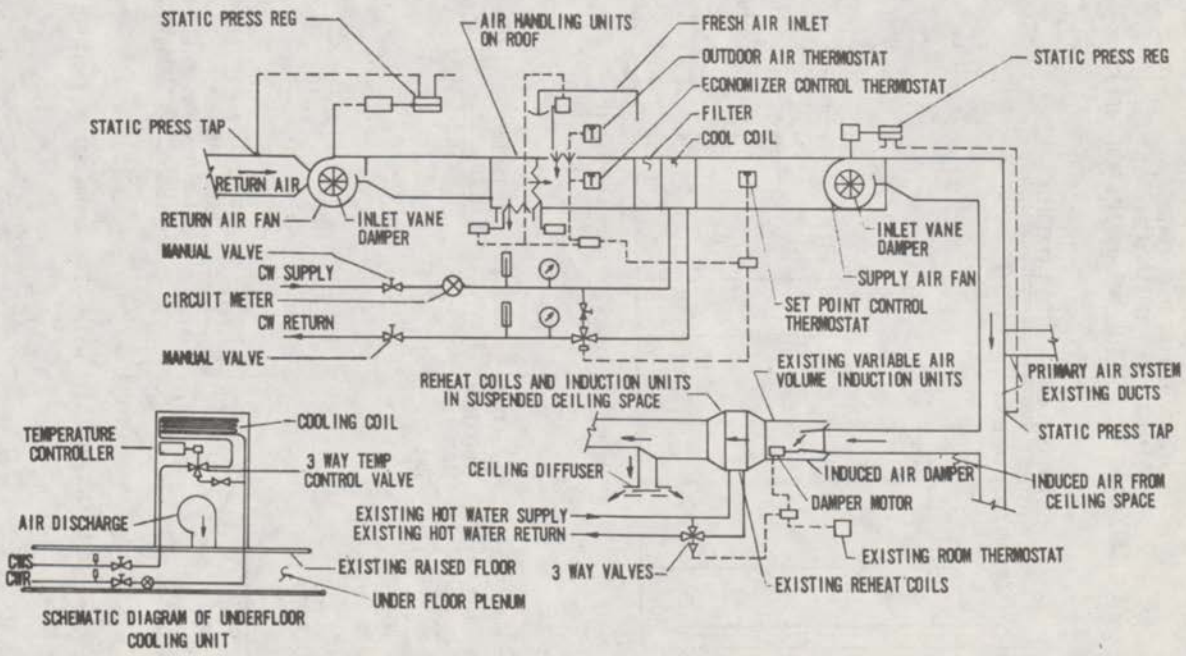


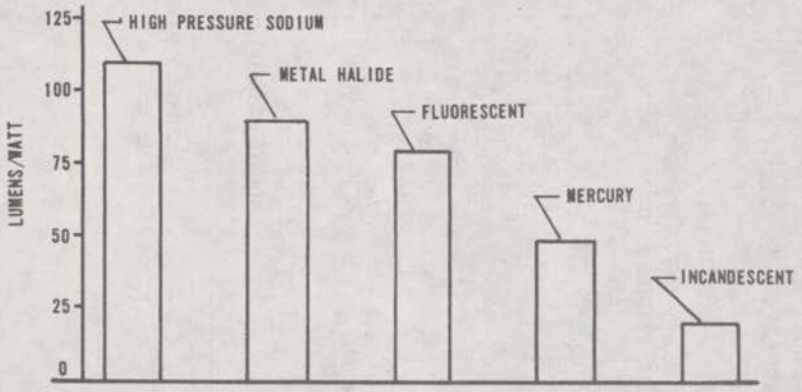
FIGURE 4

CF 4-9

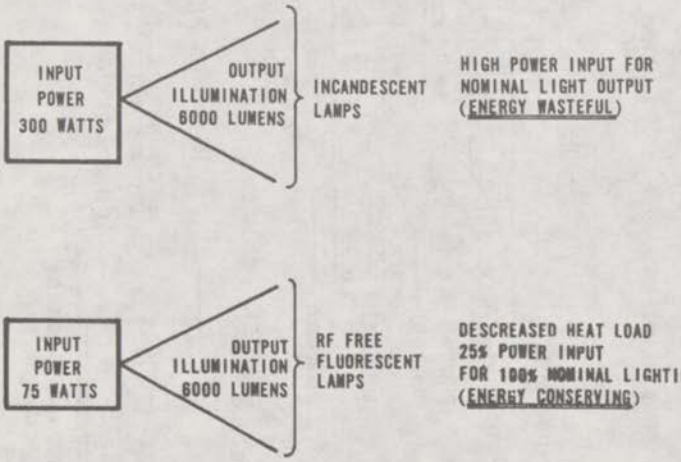
JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1980 ESTIMATES
MODIFICATIONS TO THE CENTRAL INSTRUMENTATION FACILITY

CF 4-10

TYPICAL LIGHTING SYSTEM EFFICIENCY



CENTRAL INSTRUMENTATION FACILITY LIGHTING (KSC)



~ 2680 LAMPS -225W/LAMP SAVING-TOTAL SAVING 603,000 WATTS

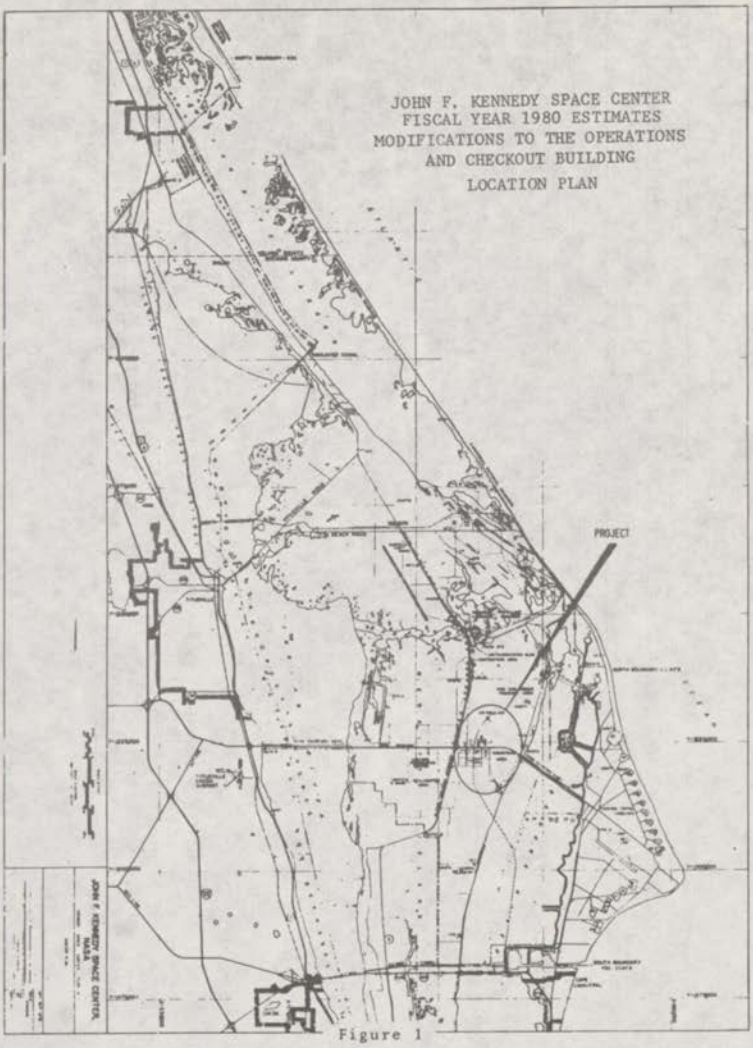

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1980 ESTIMATES
MODIFICATIONS TO THE OPERATIONS
AND CHECKOUT BUILDING
LOCATION PLAN
PROJECT
CF 4-11

Figure 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE: Modifications to the Operations and Checkout Building

INSTALLATION: John F. Kennedy Space Center

FY 1980 CoF ESTIMATE: $950,000

LOCATION OF PROJECT: Merritt Island, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of the Comptroller, Facilities Division

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	105,000	65,000	170,000
Capitalized investment	N/A	42,637,353	42,637,353
Total	105,000	42,702,353	42,807,353

SUMMARY PURPOSE AND SCOPE:

This project will provide for a reduction in the capacity of the heating, ventilating, and air-conditioning (HVAC) system in the Operations and Checkout (O&C) Building (M7-355) to obtain the maximum conservation of energy without degradation of the systems. The modifications to the HVAC system will include the conversion of the dual duct and single duct reheat systems to an efficient system incorporating Variable Air Volume (VAV) and/or bypass features, modifications to air supply and exhaust systems in intermitted use spaces, modification to controls, reduction of air through ventilation systems, reduction of air volume to actual cooling/heating

loads, and adjustment of fresh, exhaust, and relief air for infiltration control. Also included in the project will be the treatment of all windows with low-cost triple glazing systems for conductive/radiative control.

PROJECT JUSTIFICATION:

The O&C Building is the prime center for Space Shuttle Payload activities including the Spacelab missions. The building houses a large office area, laboratory and control area with monitoring and control equipment sensitive to temperature and humidity, and the assembly and test area which is maintained as a semi-clean room for work on payloads. The HVAC systems currently installed in the O&C Building exceed the capacity required to support current and future programs. Significant energy and cost savings in the operation of this building can be achieved through conversion to VAV systems, addition of discriminatory controls to the remainder of the building (the administration and office area will have discriminatory controls added in a prior year project), modifications to the zones and systems to allow shutdown of selected areas and reduction in the heating and cooling loads, and modifications to the air circulation system.

There are periods in the spring and fall when the single and double duct and multizone HVAC systems heat and cool at the same time in an effort to provide comfort. These systems were designed and installed at a time when energy was considered plentiful and cheap. The principal criteria at that time was to attain a low-cost initial installation. Though the systems are performing well, this concept is costly to operate and wastes energy. Modifying to VAV will reduce the energy required when only the actual air volume necessary to condition the inside air is used.

Installation of discriminatory and anticipatory controls will result in savings in use of heating oil and refrigeration power since it will result in a more efficient and timely conditioning of the air throughout the building.

A significant reduction in electric power and oil consumption can be achieved if the air circulation in each individual air handling system is adjusted to that required to satisfy each particular zone heating/cooling load. The required flow rates vary from 20 percent to 110 percent of the original design loading.

The treatment of the windows will reduce the heating and cooling load on the HVAC system. Several options were reviewed and the triple glazing proved to be the optimum since it results in significant energy savings, is simple to install, and is cheaper than other effective methods.

The implementation of this project will result in energy savings totalling 46×10^9 BTU's/year. This provides a less than 6-year payback period making it a very effective and attractive investment.

IMPACT OF DELAY:

Failure to implement this project will not allow this attractive cost savings to be realized on a timely basis.

PROJECT DESCRIPTION:

This work within the O&C Building will involve modifying the existing hot and cold air mixing boxes in the Administration and Engineering area to convert them to VAV, and modifying the associated blowers. Discriminatory and anticipatory controls will be added to the existing environmental control systems. These controls, used in conjunction with the Utilities Control System (UCS), will provide responsive changes in air handlers, hot decks, cold decks, chilled and hot water temperatures to automatically meet changing load requirements. Controls for the dual duct systems and multizone systems will consist of new room thermostats, master and slow controls, sensors, transmitters, receivers, controllers, cold deck and hot deck thermostats, return air humidistats, hardware interface modules and connections to the UCS. The reduction in air circulation will be accomplished by replacing pulleys and belts on supply air fans with appropriate sized units; removing the return air fan wheels, scrolls, shafts and motors from the fan housing where the supply fan can deliver the reduced flow rate; installing blanking plates in ceiling diffusers sized to obtain minimum acceptable air distribution; reducing exhaust and outside air to the appropriate rates; and reducing fan motor sizes in conjunction as appropriate.

In addition, modifications to the 21,415 square feet (1990 square meters) of existing window installations from single glazing to triple glazing will be accomplished by installing a pre-fabricated plastic frame covered on both sides by an inhibited polyester film.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	950,000
Variable air volume mixing box conversions	EA	547	903.00	494,000
Discriminatory controls	LS	---	---	280,000
Reduce air circulation	LS	---	---	140,000
Window treatment	SF	21,415	1.68	36,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				950,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Site Plan
Figure 3 - Operations and Checkout Building

OTHER EQUIPMENT SUMMARY:

There is no other equipment required for this facility project.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

There is no future funding required for this facility project.

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1980 ESTIMATES
MODIFICATIONS TO THE OPERATIONS AND CHECKOUT BUILDING

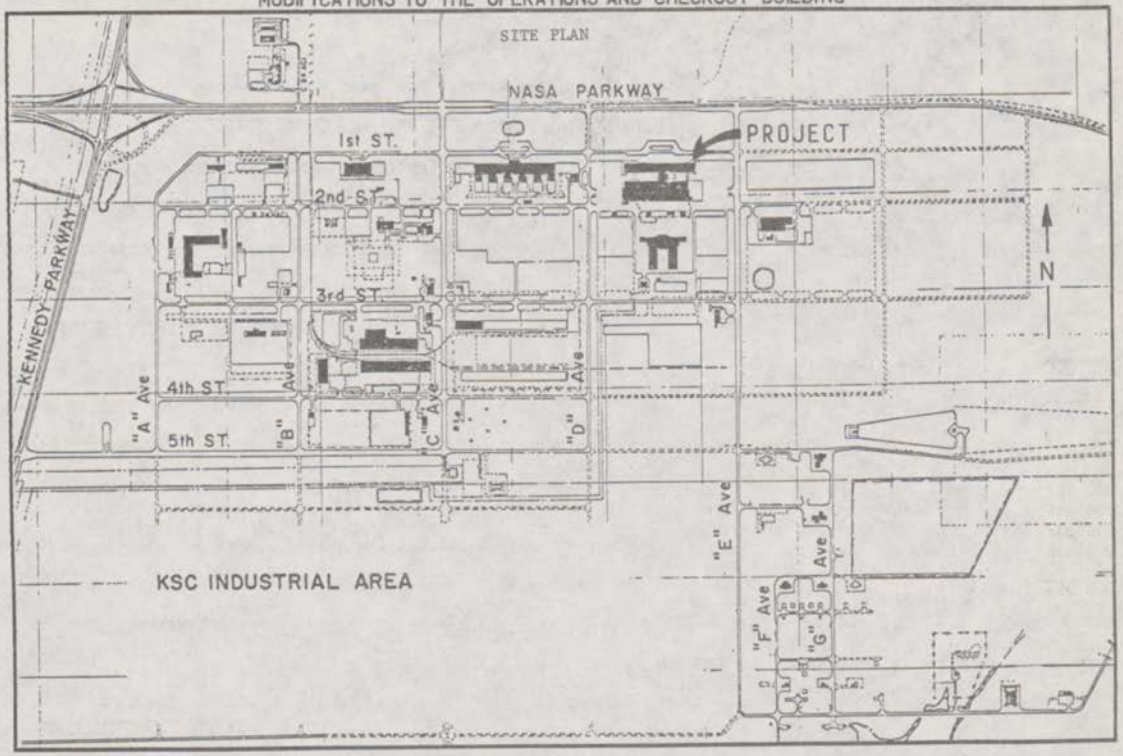


FIGURE 2

CF 4-16

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1980 ESTIMATES
MODIFICATIONS TO THE OPERATIONS AND CHECKOUT BUILDING

OPERATIONS AND CHECKOUT BUILDING ARRANGEMENT

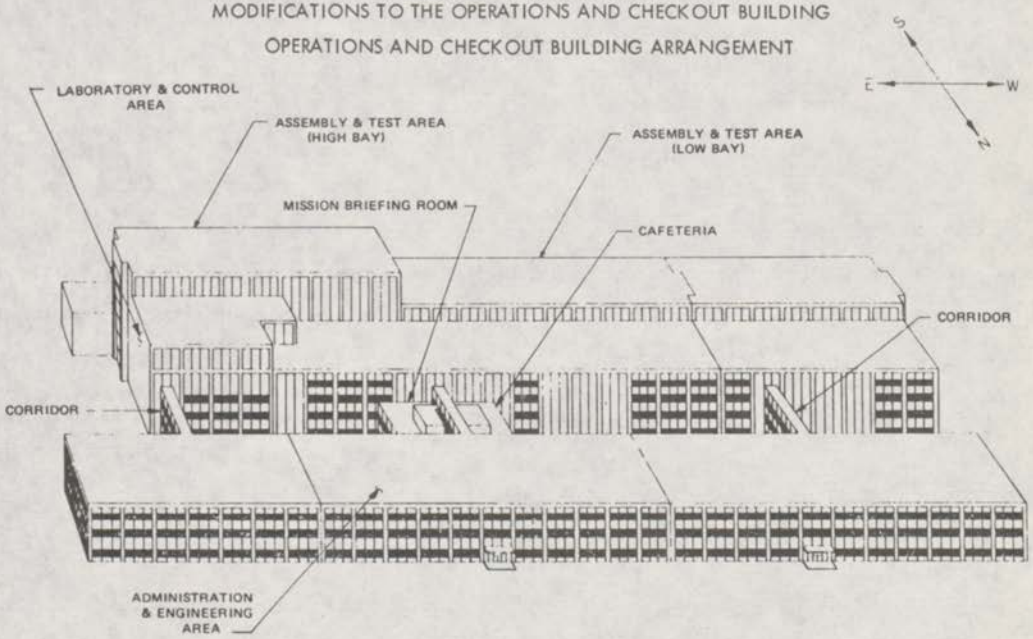


FIGURE 3

CF 4-17

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

SUMMARY

LANGLEY RESEARCH CENTER

	Amount	Page No.
Office of Aeronautics and Space Technology:		
Modifications of Model Support System 8-Foot High Temperature Structures Tunnel	1,410,000	CF 5-1
Modifications to 8-Foot Transonic Pressure Tunnel	2,000,000	CF 5-8
Modification of Transonic Dynamics Tunnel	970,000	CF 5-16
Rehabilitation and Modification of Gas Dynamics Laboratory	3,600,000	CF 5-22
Total	7,980,000	

LANGLEY RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

MODIFICATIONS OF MODEL SUPPORT SYSTEM 8' HIGH TEMPERATURE STRUCTURES TUNNEL (1265)

LOCATION PLAN

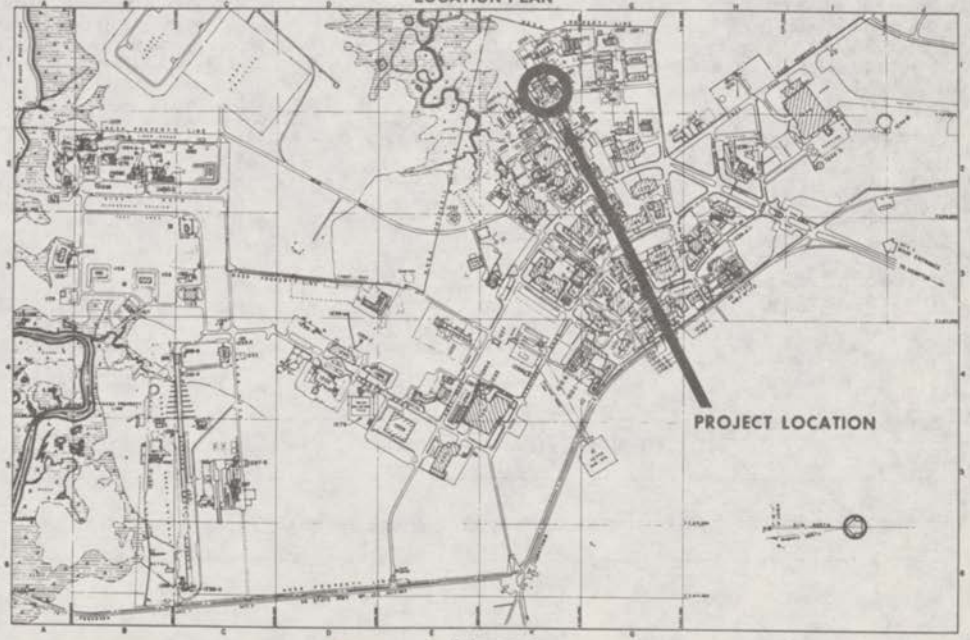


Figure 1

CF 5-1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE: Modifications of Model Support System 8-Foot High Temperature Structures Tunnel (1265)

INSTALLATION: Langley Research Center

FY 1980 CoF ESTIMATE: $1,410,000

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Technology

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	126,000	---	126,000
Capitalized investment	N/A	16,209,432	16,209,432
Total	126,000	16,209,432	16,335,432

SUMMARY PURPOSE AND SCOPE:

The modifications of the Model Support System 8-Foot High Temperature Structures Tunnel (HTST), Building 1265, (Figures 1 and 2) provide for the addition of: (1) a Lifting-Surface Test Apparatus (LSTA), for simulating the tip portion of a wing-elevon or a complete fin of a hypersonic vehicle; (2) a new first minimum section for the wind tunnel made of a material such as silicon nitride; and, (3) a sweep-type pressure-temperature calibration mechanism. Since the late 1960's, the 8-Foot HTST has provided the only capability for large scale testing in realistic hypersonic flows. However, an aerothermodynamic data base necessary for the assessment of the behavior of critical structural interface regions has not been available due to the lack of the above

modifications. The only practicable method for obtaining this data base is through the use of a wind tunnel. This facility is unique in this field.

PROJECT JUSTIFICATION:

The LSTA, the new, first minimum section and the calibration mechanism will provide the proper flow and known flow conditions needed to investigate and resolve critical design problems for hypersonic vehicles and space transportation systems. These problems involve interactions of different thermostructural concepts at interface regions (leading edge/wing box) and local areas of high heating due to complex structure/flow interactions. These cannot be adequately predicted by analysis or simulated in small scale wind tunnel tests. Proof that these deficiencies can lead to problems in flight is evidenced by the buckling of the X-15 leading edges, which is attributed to inadequate knowledge of interference heating and the resultant thermal stress in the leading edge segments. These modifications to the 8-Foot HTST will provide the ground-based testing capability required to obtain the necessary aerothermodynamic data base and, permit the structural concept studies and evaluations needed to develop confidence in the design of wing-elevon structures for possible Shuttle component retrofit and for future hypersonic aircraft-type vehicles.

The LSTA provides the best feasible approach to correlation of ground-based data with flight data obtained from the Shuttle and future hypersonic vehicles and, in addition, would readily permit ground-based studies of any anomalous behavior observed in flight. The modified radiant heater configuration will provide needed test capability (preheat and extended trajectory) in the 8-Foot HTST for the other large wing-type components. Only a limited area of a large model can now be heated with the existing equipment.

The ceramic first minimum section, as shown in Figure 3 - Schematic Variations in Hot Core Size, will eliminate several disadvantages of the existing first minimum metal section, including the requirement to monitor and limit the maximum surface temperature during each run, repair of cracks which develop after only a few runs, and polishing the surface (which discolors after each high-energy run), in order to minimize the heat transfer during the next run. In addition, the metal component must be film cooled with cold air, which reduces the hot core diameter in the test section region from a potential six feet (1.8 meters) to about four feet (1.2 meters). Since the film cooling will be minimized and possibly eliminated, the silicon nitride first minimum section will provide a larger, more uniform, hot gas test core. The larger test core will allow simultaneous testing of the entire surface of a large model or apparatus, such as the LSTA.

The calibration mechanism will provide a means of obtaining a measurement of the free stream flow conditions in the test section just prior to model insertion during each tunnel run. These measurements will provide direct information on the flow environment of the model needed to produce more accurate research data than using measured settling chamber flow conditions and relying on the settling chamber-to-test section calibration

to predict the model flow environment. The mechanism will also be used to directly assess the effects of changes in tunnel component configuration which are intended to improve both the flow conditions and facility operation. In addition, it will provide a means of early detection of even minor unexpected changes, in the tunnel operating configuration, before they become major repair problems.

IMPACT OF DELAY:

This is the only facility in the "free world" capable of obtaining data using large to full scale test specimens. Because wind tunnel testing is the only practical method of effectively obtaining a data base for this kind of work, further research could become cost prohibitive.

PROJECT DESCRIPTION:

This project provides for LSTA and model support system modifications, a new, first minimum section, and a sweep-type pressure-temperature calibration mechanism. The LSTA will consist of a rigid internal structure of ribs and spars with replaceable boiler plate leading edge, surface structure, wing tip closure, and elevon. The apparatus will have a minimal six-foot (1.8 meter) span and six-foot chord, and will be designed to allow for variation in pitch, yaw, control-surface angle, variation in leading-edge sweep and radius, and variation in lifting surface tip contour and closure. The model support system modifications include adding the capability for varying the yaw angle and repositioning and installing the two large heater panels for preheating each model run prior to insertion in the tunnel test stream.

The ceramic first minimum section, as shown in Figure 3 - Schematic Variations in Hot Core Size, will be similar to the existing section, but fabricated of a material such as silicon nitride which can withstand extremely high temperatures and thermal shock without deterioration. The calibration mechanism will be pneumatically-operated and installed permanently in the test section pod. The mechanism will be designed with the capability for both variable longitudinal and vertical positioning in the test section allowing measurements at arbitrary model locations.

PROJECT COST ESTIMATE:

The project cost estimate is based on an updated Preliminary Engineering Report.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	---
Equipment	---	---	---	1,410,000
New lifting surface test apparatus (LSTA)	LS	---	---	300,000
Installation of model support system	LS	---	---	555,000
Replacement of first minimum section	LS	---	---	275,000
Installation of pressure calibration mechanism	LS	---	---	280,000
Fallout Shelter (not feasible)	---	---	---	---
Total				1,410,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Site Plan
Figure 3 - Schematic Variations in Hot Core Size - Minimum Sections

OTHER EQUIPMENT SUMMARY:

At present, there is no foreseen requirement.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

There is no foreseen requirement for future CoF funding for this project.

LANGLEY RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

MODIFICATIONS OF MODEL SUPPORT SYSTEM 8' HIGH TEMPERATURE STRUCTURES TUNNEL (1265)

SITE PLAN



FIGURE 7

CF 5-6

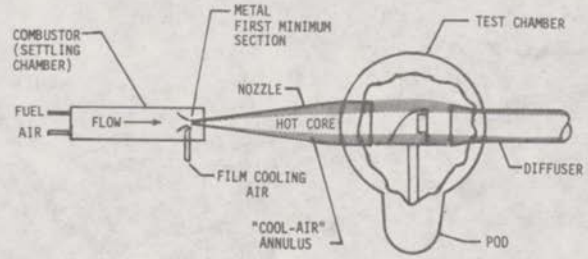
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LANGLEY RESEARCH CENTER

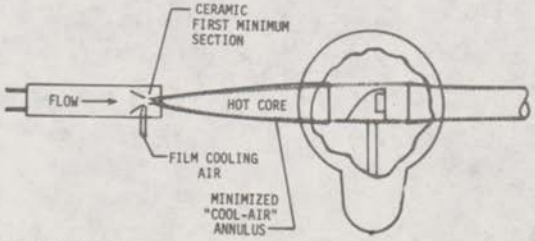
FISCAL YEAR 1980 ESTIMATES

MODIFICATIONS OF MODEL SUPPORT SYSTEM 8' HIGH TEMPERATURE STRUCTURES TUNNEL (1265)

SCHEMATIC VARIATIONS IN HOT CORE SIZE



HOT CORE WITH EXISTING METAL FIRST MINIMUM SECTION



ADVANTAGES

BIGGER CORE
LESS MAINTENANCE
FEWER SHORT RUNS

HOT CORE WITH NEW CERAMIC FIRST MINIMUM SECTION

Figure 3

CF 5-7

LANGLEY RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

MODIFICATION OF 8' TRANSONIC PRESSURE TUNNEL

(640)

LOCATION PLAN

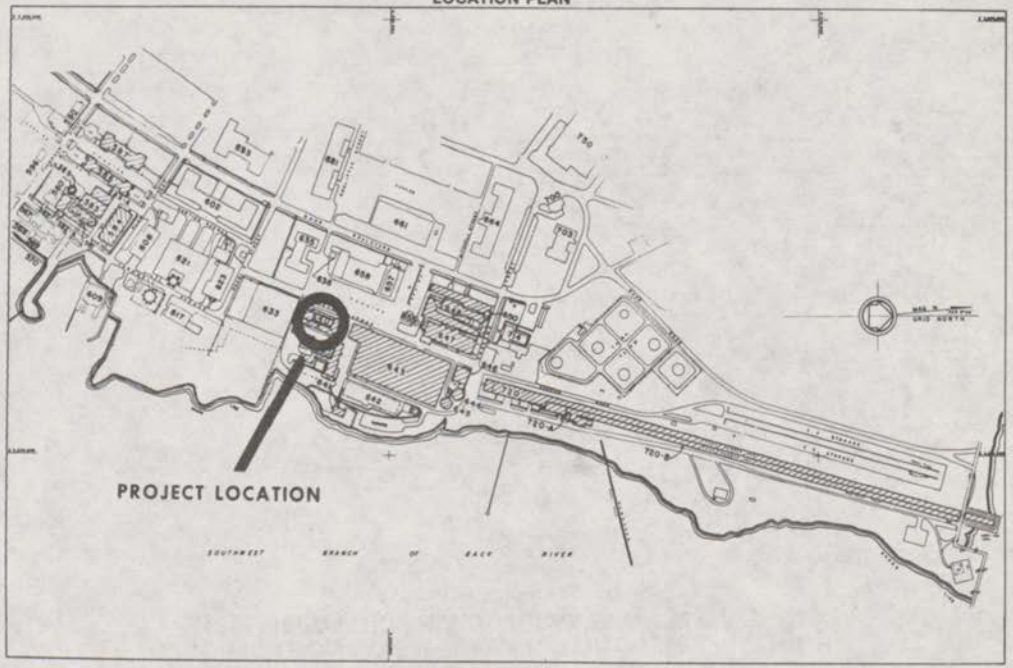


Figure 1

CF 5-8

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE:	Modification to 8-Foot Transonic Pressure Tunnel (640)
INSTALLATION:	Langley Research Center
FY 1980 CoF ESTIMATE:	$2,000,000

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Technology

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	188,000	---	188,000
Capitalized investment	N/A	8,901,719	8,901,719
Total	188,000	8,901,719	9,089,719

SUMMARY PURPOSE AND SCOPE:

This provides for modification to the 8-Foot Transonic Pressure Tunnel (TPT), Building 640, Langley Research Center (LaRC) (Figure 1). This work includes the following: (1) installation of low-turbulence screens, honeycomb, and noise baffles to reduce the levels of turbulence and noise in the test section to the low levels required for laminar flow research; (2) replacement of the existing 32 fan blade retaining boxes with ones of a new design to reduce the maintenance downtime and cost experienced with the present boxes. The TPT has been in operation since 1953 and is considered to have good flow quality and low turbulence characteristics. LaRC has been assigned the mission to develop the broad aerodynamic systems technology for long haul aircraft.

Specifically, viscous drag reduction through laminar flow control is required to provide for improved efficiency (20-30 percent) in fuel consumption for long haul aircraft in the 1990 time frame and beyond. In support of this development, the TPT has been selected as the best NASA candidate for laminar flow research when equipped with honeycomb screens to reduce strong turbulence, and acoustic treatment to decrease noise disturbances to acceptable levels. This project is, therefore, in direct support of the Aircraft Energy Efficiency (ACEE) Program. In order to fulfill this role, it is necessary that Langley research staff have available a transonic wind tunnel of appropriate size and flow quality for the extensive periods of time required for the meticulous and time consuming boundary layer experiments required for the laminar flow research program. Research in this facility will be directed at developing methods of improving the aerodynamics efficiency of both civil and military aircraft configurations for flight at high subsonic and transonic speeds.

PROJECT JUSTIFICATION:

The 8-Foot Transonic Pressure Tunnel (TPT) is a prime tool used in the development of advanced technologies and supercritical wing aerodynamics, and winglets and propulsion system integration. This work is necessary to support the development of efficient aircraft configurations intended for flight at high subsonic and transonic speeds. The more basic aerodynamic research required for the design and optimization of aircraft to achieve the economic benefits of extensive laminar flow has proceeded and will continue to proceed at a slow pace until a suitably equipped wind tunnel becomes available. Because of the aerodynamics design of the 8-Foot TPT circuit and its larger contraction ratio (20 to 1), it has at present, as verified by extensive recent measurements, excellent flow quality characteristics which, when enhanced by the proposed addition of low turbulence screens and honeycomb and noise baffles, will meet the extreme flow quality essential for this very important laminar flow research.

Improvements in aircraft manufacturing techniques, together with the development of means of keeping the leading edge of a wing free of bug deposits and possibly ice, would seem to make possible the achievement in practice of extensive laminar flow, with a consequent large reduction in drag and fuel consumption which has been theoretically possible, but not practical, in the past. To most effectively capitalize on this possibility, however, considerable aerodynamic research is required to improve the understanding of the basic mechanisms, to extend previous work to high subsonic speeds, and to combine both supercritical and laminar flow principles. This research requires a large wind tunnel with high subsonic speed capability, low turbulence and noise levels, reasonable Reynolds number capability, close control of test conditions, and the long run times necessary for wind tunnel flow stabilization, and for running boundary layer experiments.

The replacement of the existing fan blade boxes (Figure 2) is essential because the boxes are approaching their fatigue limit. This is evidenced by the magnetic particle inspection of each box on an annual basis since 1976. To date, these non-destructive tests have revealed that 30 of the 32 boxes have had fatigue cracks

requiring repair. Because of the continuing occurrence of these cracks, there is a possibility of the fan blades separating from the blade boxes. If this were to occur, extensive damage could be done to the facility.

IMPACT OF DELAY:

If this project is not implemented in the 1980 timeframe, critical research in support of the ACEE Program will be delayed by the lack of a suitable facility. At the present time, this testing is envisioned as being conducted in CY 1981. Because this ground facility research is a needed prerequisite to a planned flight investigation, any delay beyond an FY 1980 start for this project will seriously impair the probability for successful accomplishment of the flight test program and hence the timely introduction into new generation commercial aircraft development.

PROJECT DESCRIPTION:

The basic elements of the modification to the 8-Foot Transonic Pressure Tunnel are the low turbulence screens and honeycomb, noise baffles (Figure 3) for flow quality improvement, and blade retaining boxes for increased efficiency of operation.

1. Screens and Honeycomb

Low turbulence screens and honeycomb will be placed across the stilling chamber just downstream of the cooling coils and turning vanes. Three additional 36-foot (11 meters) diameter screens will be placed across the stilling chamber just ahead of the contraction section. (Aerodynamic fairings are required over the screen support beams.)

2. Noise Baffles

Two sets of noise baffles will be installed, one ahead of, and one behind the tunnel fan section. These baffles will consist of structural support members wrapped with an outer covering of perforated metal and the interior filled with an acoustic material. These members will transmit the aerodynamic drag and static loads from the baffles to the tunnel shell.

3. Blade Retaining Boxes:

The 32 existing blade retaining boxes will be replaced with boxes of a new design. This design with improved materials, fabrication techniques, and inspection procedures will alleviate fatigue failure by a uniform distribution of the blade loads transmitted to the boxes.

PROJECT COST ESTIMATE:

This project cost estimate is based on a completed Preliminary Engineering Report.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	---
Equipment	---	---	---	2,000,000
Modification for low turbulence screens and honeycomb	LS	---	---	700,000
Modification for noise baffles	EA	2	450,000	900,000
Replacement of fan blade boxes	EA	32	12,500	400,000
Fallout Shelter (not feasible)	---	---	---	---
Total				2,000,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Fan Blade Box
Figure 3 - Low Turbulence Screen and Baffles

OTHER EQUIPMENT SUMMARY:

Approximately $1.9 million of other associated equipment is involved in this project.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

An automated model support system is being investigated for future incorporation in the 8-Foot TPT. Such a system would provide an energy savings which would permit a payback in less than five (5) years.

LANGLEY RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

MODIFICATION OF 8' TRANSONIC PRESSURE TUNNEL
(640)

ASSEMBLED VIEW OF BLADE AND BLADE BOX

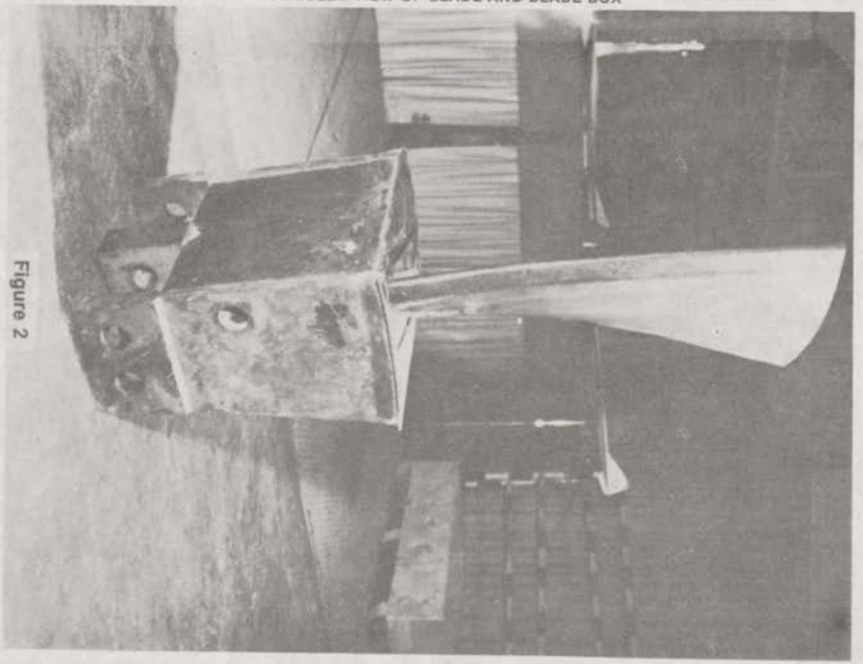


Figure 2

LANGLEY RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

MODIFICATION OF 8' TRANSONIC PRESSURE TUNNEL (640) LOW TURBULENCE SCREENS AND NOISE BAFFLES

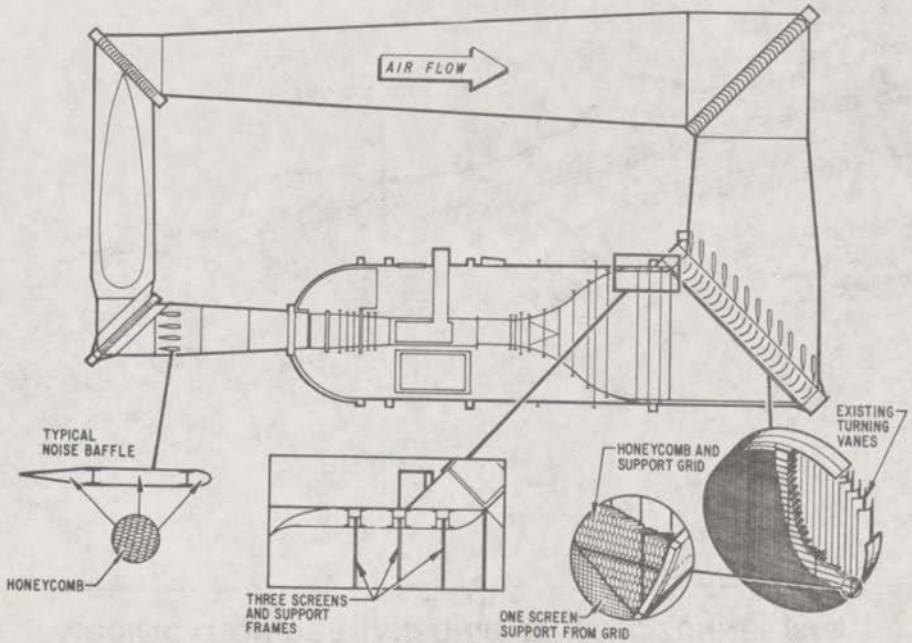


Figure 3

CF 5-15

LANGLEY RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

MODIFICATION OF TRANSONIC DYNAMIC TUNNEL (648)

LOCATION PLAN

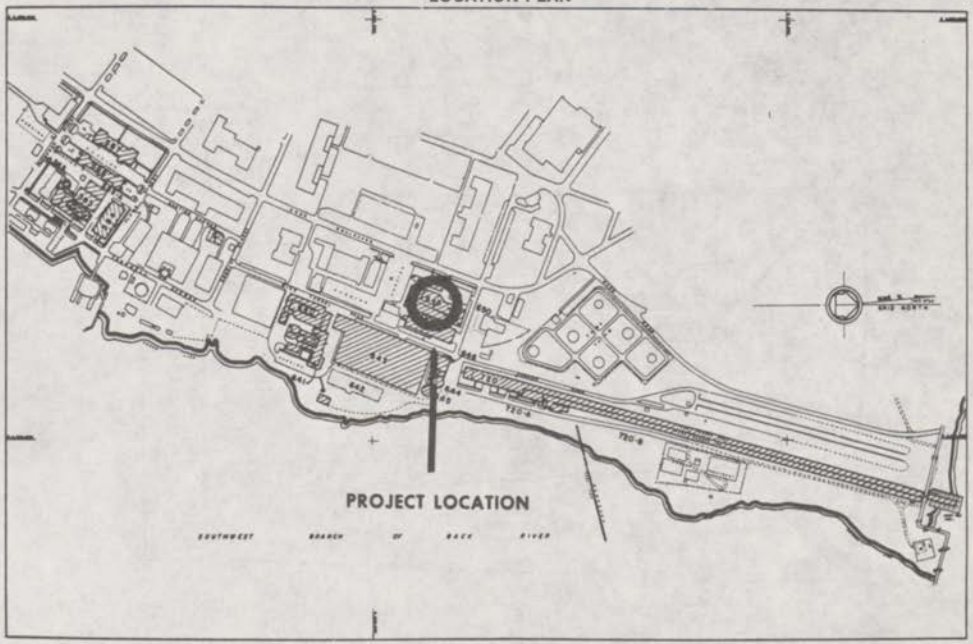


Figure 1

CF 5-16

PROJECT TITLE: Modification of Transonic Dynamics Tunnel (648)

INSTALLATION: Langley Research Center

FY 1980 CoF ESTIMATE: $970,000

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Technology

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	50,000	---	50,000
Capitalized investment	N/A	14,530,794	14,530,794
Total	50,000	14,530,794	14,580,794

SUMMARY PURPOSE AND SCOPE:

The Langley Research Center's (LaRC) Transonic Dynamics Tunnel (TDT) facility is a unique National facility which is dedicated to work in the field of aeroelasticity (Figure 1). The facility is used to verify the flutter and aeroelastic characteristics of most U.S. high-speed aircraft designs; for active controls, and rotorcraft aeroelastic research; for flutter, buffet and ground-wind loads testing of Shuttle and other launch vehicles; and, for confirmation of unsteady transonic flow theory. The primary purpose of this project is to provide for the replacement of the cooling tower. This is necessary due to the existing safety hazard presented by its age and continued use.

PROJECT JUSTIFICATION:

The LaRC Transonic Dynamics Tunnel (Figure 2) has characteristics and features which make it a unique and much used (over two-year backlog of tests) National facility for work in the field of aeroelasticity. Salient characteristics are its transonic, continuous and variable-density flow, and 16-foot x 16-foot (4.9 meters x 4.9 meters) test section. Unique features are the ability to use Freon-12 gas or air as a test medium, a computerized data acquisition system designed for multi-channel dynamics data, special model cable mount systems, a "flutter stopper," safety screens, and good visibility of the model during tests. The facility is used to verify, through tests of aeroelastically-scaled models, the flutter and aeroelastic characteristics of most high-speed U.S. aircraft, including the F-15, F-16, F-111, F-111 TACT II, and the B-52 multimode flutter suppression test vehicle. It is used for active control and rotorcraft research programs such as Aircraft Energy Efficiency (ACEE), Supersonic Cruise Aircraft Research (SCAR), Drones for Aerodynamic Testing (DAST), and Rotor Systems Research Aircraft (RSRA). In addition, it is used for flutter, buffet and ground-wind loads testing on Shuttle, and for verification of unsteady transonic flow theory.

The existing 10,000 gallon-per-minute tower (37,850 liters per minute) is 25 years old, and the structural members, tower fill water distribution systems, eliminators, fans, fan stacks, decks and deck joists are badly deteriorated. Replacement of the cooling tower is required to provide the capability of handling a cooling capacity of 15,000 gpm (56,775 liters per minute). This is necessary to accommodate future requirements to handle the repowering of the drive system and other tunnel components. The structure of the tower has deteriorated and could present a hazard since the structure is elevated approximately 35 feet above ground. Although the storage basin is underground and is covered, rehabilitation is necessary to prevent the entrance and accumulation of debris.

IMPACT OF DELAY:

The cooling tower is 25 years old and requires replacement. Failure to replace it could seriously impact the safety, as well as the operation, of the facility.

PROJECT DESCRIPTION:

The new cooling tower will be constructed in the existing parking lot adjacent to the TDT. It will have a three (3) cell, elevated basin with each cell providing 5,000 gpm (18,925 liters per minute) cooling capacity. The project provides for the completion of two cells which will supply 10,000 gpm (37,850 liters per minute) cooling capacity for the TDT. The third cell will be completed when the TDT power is increased, which will be in the future.

The return lines will be sized to accommodate the increased capacity. Demolition of the existing tower, steel support structures, and associated systems will commence after the new tower is in operation.

PROJECT COST ESTIMATE:

The project cost estimate is based on an updated Preliminary Engineering Report.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	---
Equipment	---	---	---	970,000
Cooling tower installation	LS	---	---	804,000
Electrical installation	LS	---	---	50,000
Piping installation	LS	---	---	96,000
Demolition	LS	---	---	20,000
Fallout Shelter (not feasible)	---	---	---	---
Total				970,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Site Plan

OTHER EQUIPMENT SUMMARY:

No other collateral or non-collateral equipment is involved.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

Future requirements to complete this project, as currently planned, include rehabilitation of the freon reclamation system and the repowering of the tunnel in order to increase the density of the test medium. In addition, a model deformation measurement system is planned. The cost estimate for this work is approximately $8-10 million.

LANGLEY RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES

MODIFICATION OF TRANSONIC DYNAMICS TUNNEL (648)

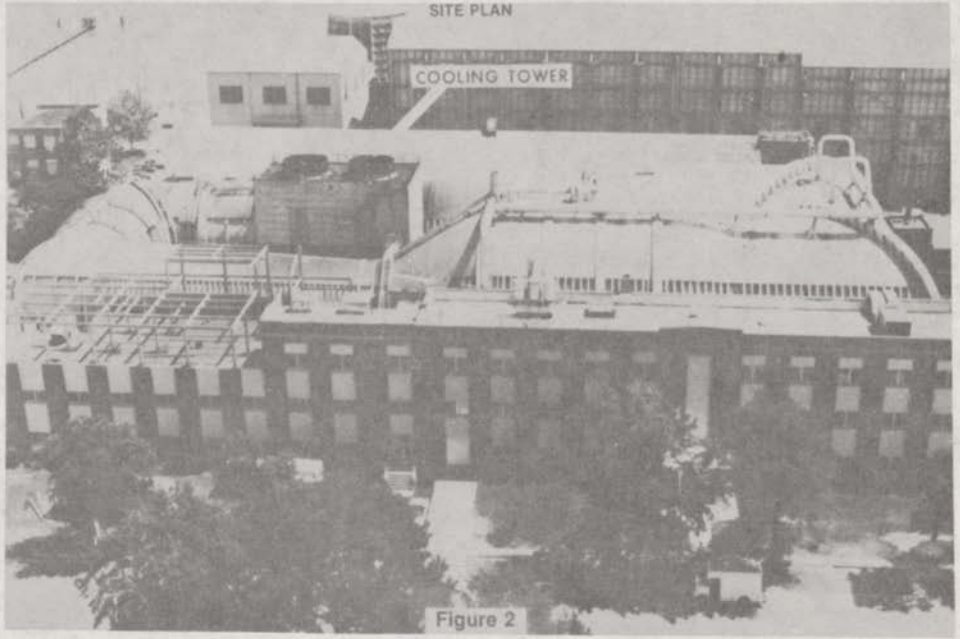


Figure 2

CF 5-21

LANGLEY RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

REHABILITATION AND MODIFICATION OF GAS DYNAMICS LABORATORY (1247)

LOCATION PLAN

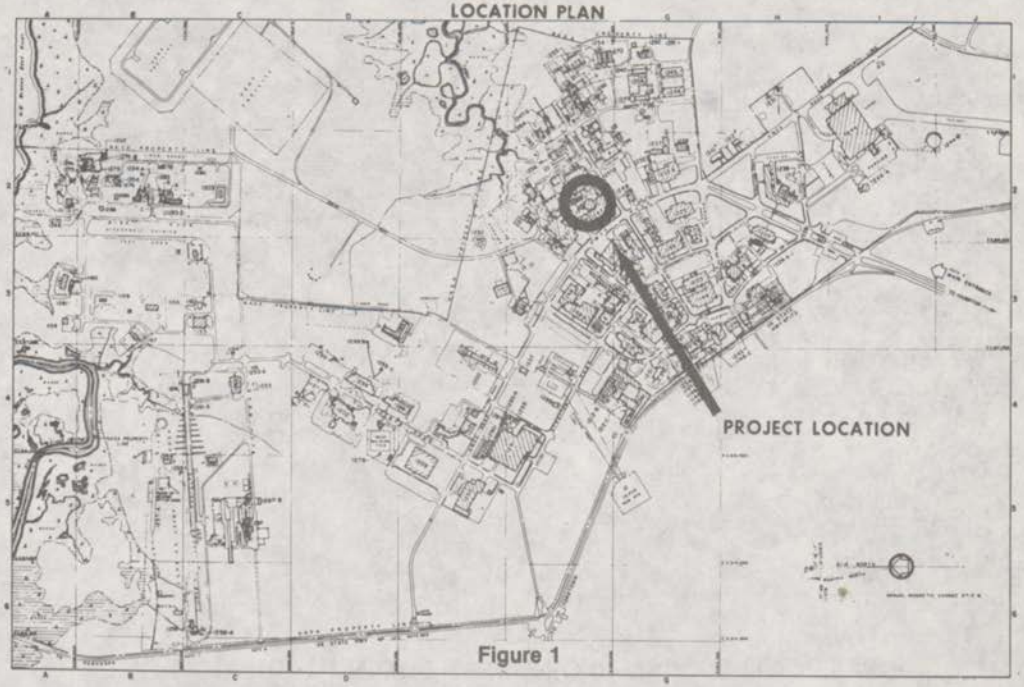


Figure 1

CF 5-22

43-843 O - 79 - 38

PROJECT TITLE: Rehabilitation and Modification of Gas Dynamics Laboratory (1247)

INSTALLATION: Langley Research Center

FY 1980 CoF ESTIMATE: $3,600,000

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Technology;
Office of the Comptroller, Facilities Division

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	300,000	---	300,000
Capitalized investment	N/A	10,614,875	10,614,875
Total	300,000	10,614,875	10,914,875

SUMMARY PURPOSE AND SCOPE:

This project provides for the rehabilitation and modification of test cells, offices, and support equipment located within the Gas Dynamics Laboratory (GDL) (Figure 1) principally in Building 1247D, at the Langley Research Center (LaRC). The remaining areas of the GDL, Buildings 1247A, B and E, are planned to be done in a subsequent year. Building 1247D contains the more critical items that are in need of rehabilitation and/or modification. New tunnels and research equipment have been added since 1951 to reflect changes in research emphasis; however, none of the older equipment has been rehabilitated or subjected to a major overhaul. This

project emphasizes the overhaul, upgrading and modernization necessary to assure future operations meeting safety, energy and performance requirements of this facility. Research in this facility supports many high priority NASA projects, such as laminar flow control, turbulent drag reduction, advanced supersonic transport, sonic boom alleviation, Space Shuttle, advanced space transportation systems (follow-on Shuttle), airbreathing launch vehicles, planetary entry probes, hypersonic aircraft (both civil and military), and hypersonic missiles.

PROJECT JUSTIFICATION:

The GDL is a 27-year old facility incorporating several types of wind tunnels and test apparatus. New tunnels and facility equipment have been added over the years reflecting changes in research emphasis; however, none of the older equipment has been rehabilitated or subjected to a major overhaul.

The GDL is critical to research over a wide speed range up to Space Shuttle reentry, and it is especially valuable in the Mach number range from approximately three to eight, where the next generation of advanced supersonic transports and hypersonic aircraft and missiles will operate. This laboratory of several small, flexible wind tunnels can test inexpensive, readily installed and easily modified models over a wide Mach number range. Each of the test cells has at least one special experimental feature, and thus each tunnel provides unique testing capabilities. Examples of such special features are high-speed model injection mechanisms, "quick-start" air supplies, test sections adapted for phase-change-paint heating rate techniques, low noise "quiet" flows, laser-doppler systems, Gama radiation instrumentation, and varying Reynolds numbers (very high or low, or with ability to vary by a factor of over 100 in one tunnel).

The east wing of the GDL (Building 1247D) houses several major wind tunnels (Figure 2), a variety of space-oriented test cells, plus additional small experiments. Support equipment for these test cells includes a large, high-pressure air distribution system, two large vacuum systems, storage tanks, cooling water systems, vacuum spheres, air heaters, etc.

While additions and changes to the test cells have been made over the years, the support equipment and the building structure are virtually identical with the original installation. Heavy use of this equipment has caused deterioration and increased maintenance costs.

This project completes all the necessary work for the critical items in Building 1247D (Figure 2). Because of the criticality of a potential failure of the deteriorating cooling tower (Building 1247C) and the possibility of pollution from oil being emitted by a precipitator (Building 1247B) that is beyond repair and needs replacing, these items have been included in this project also.

IMPACT OF DELAY:

Many of the components of this facility have been in existence since 1951 and have not had a major overhaul. If this facility is to continue in operation, rehabilitation and modification work of this nature to maintain the equipment must be performed now. If this project is delayed, possible failure of key components of this facility will impact operation of important research work being performed in this facility.

PROJECT DESCRIPTION:

The work to be performed on the GDL as part of this project includes the following:

1. Repair of Water Cooling Towers

Engineering inspection of the cooling towers, presently composed of five cells, indicates a need for repair by replacement. Since a large cooling load recently was permanently disconnected from this water system, it is now possible to accommodate future loads with only three cells. After provision of the three new cells, by this project, the remaining two cells will be dismantled. These cooling towers serve the entire GDL as well as the Hypersonic Propulsion Facility, Building 1221 and the central air compressor station.

2. Rehabilitation of Mechanical Equipment

Mechanical equipment includes a vast array of pumps, blowers, compressors, heat exchangers, valves, etc. The following paragraph describes the major components to be replaced.

The replacement of two electrostatic precipitators is necessary. Their present condition requires extensive repairs annually to insulators, wires, and sheet metal housing. One of the precipitators of the vacuum systems in Building 1247B has degenerated to such an extent as to permit unacceptable exhaust pollution. The two large vacuum systems, containing a total of eight pumps, are used almost daily. An overhaul is long overdue since no major overhaul (bearings, seals, cooling water passages) has been performed on either the pumps or their drive motors. A recent extension of the high-pressure air system has left one wind tunnel without proper isolation valving. The addition of a remotely operated isolation valve will improve safety and eliminate extensive manual operation. Two cooling tower water pumps were placed in service in 1951 and are run daily. Repairs are no longer cost effective. Replacement of the pumps with improved equipment is necessary to avoid delays that could impact operation of the facility. Three existing valves in the 3,000 psi (20,670,000 newtons per square meter) air system have been found to be defective. Replacement of these valves is necessary to allow for a more efficient and safer operation.

Lastly, in the Mach 8 tunnel a new variable density nozzle and a flow field survey probe are required. The existing variable density nozzle can not be used for the planned hypersonic research testing in this tunnel. The existing nozzle does not have the capability of providing the accuracy needed to achieve the increased requirement for hypersonic force measurements. The survey probe will provide an increased capability that does not presently exist. It will allow temperature, pressure and flow measurements to be made across the test section during each run.

3. Rehabilitation of Air Control and Distribution System

A central control room in Building 1247D sets high-pressure air flow conditions and provides vacuum for several wind tunnels, plus scheduling, recording, and monitoring high-pressure air distribution to the entire west area of LaRC. The performance of these functions requires a large expenditure of manpower, most of which would be eliminated by automation.

Equipment operated from this control room includes two large electric air heaters, two vacuum systems, and many valves to provide pressure control, isolation, and flow routing. Air supply to Building 1247D is provided at 5,000 and 3,000 psi (34,473,800 and 20,670,000 newtons per square meter, respectively) some of which is reduced in pressure to 600 psi (4,134,000 newtons per square meter) and stored for various wind tunnel operations. Air is distributed to other LaRC facilities from this point of 600, 1,000, 1,800 and 5,000 psi (4,136,900; 6,894,000; 12,410,000; and 34,473,800 newtons per square meter, respectively).

Although valves and electrical breakers are remotely operated to a large extent, the distribution and conditioning (temperature, pressure, and flow) of air to the various test facilities is a manual process. The large and complex system contains electrical interlocking for safety purposes, but the human element is still present.

A microprocessor control system will replace the existing manual system, thus enabling each wind tunnel to be operated remotely and electronically at the desired flow parameters and routing. The results will be greater safety, elimination of manpower, and the reduction in energy brought about by the ability to more rapidly establish set points. In addition to the microprocessor installation, there will be wiring changes, relocation of valves, etc.

4. Rehabilitation of High Voltage Electrical Equipment

Equipment in this category primarily includes breakers, controlling flow from large power supplies, and breakers and tap changers controlling power flow to various electric heaters. All of this switchgear has many service cycles. Linkage is becoming worn, and operation is sometimes erratic.

In addition to replacing approximately 12 large breakers, this item includes rehabilitation of several power distribution panels, an additional motor control center and the installation of high capacity cables to one air heater.

5. Rehabilitation of Building 1247D

Building 1247D contains a floor area of approximately 43,500 square feet (4,042 square meters) divided into 12 test cells and a large shop area. Also included are various control rooms, lavatory facilities, and a full basement. This building structure was erected in 1951.

A new central absorption type air-conditioning system is to be installed to take advantage of the steam available in the summer months from the new Refuse Fired Steam Generating Facility. This new system will consolidate 15 independent air-conditioning systems into one central system and replace air-conditioning equipment that is 30 years old.

In addition to the air-conditioning, the building requires repairs to the roof and masonry walls. New windows will be installed. Plumbing fixtures will be replaced where necessary, and the fire alarm system will be upgraded.

6. Modification of Data Acquisition and Processing Capability

Present capabilities for acquiring and processing experimental wind tunnel data are limited to low frequency, low volume data samples. Wind tunnel runs are often prolonged in order to provide sufficient data sampling time. This results in increased power consumption and degraded facility utilization. In recent years, new and more sophisticated instrumentation has been routinely used to obtain experimental data; and this new instrumentation (e.g., laser velocimeter, Raman scattering, hot wires, and fluctuation gauges) generally requires extremely rapid data sampling rates and retention in huge data banks. Processing procedures for these vast volumes of data change from test-to-test and present a formidable problem in coordinating with data reduction personnel.

Installing microprocessing equipment with attendant terminals will provide the necessary speed and volume capability and will allow on-site, on-line data reduction capability. This equipment is necessary to meet present needs and will result in substantial savings of facility operation costs while providing higher quality data reduction capabilities.

PROJECT COST ESTIMATE:

The project cost estimate is based on a completed Preliminary Engineering Report.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	---
Equipment	---	---	---	3,600,000
Repair of cooling towers	LS	---	---	285,000
Rehabilitation of mechanical equipment	LS	---	---	885,000
Rehabilitation of air control & distribution system	LS	---	---	1,075,000
Rehabilitation of high voltage electrical equipment	LS	---	---	405,000
Rehabilitation of building 1247D	SF	43,500	14.48	630,000
Modification of data acquisition system	LS	---	---	320,000
Fallout Shelter (not feasible)	---	---	---	---
Total				3,600,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Site Plan
Figure 3 - Floor Plan

OTHER EQUIPMENT SUMMARY:

No other collateral equipment is involved.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

Rehabilitation and modification of Gas Dynamics Laboratory, Building 1247, is planned for FY 1981, at a cost of approximately $3,200,000. This project will include the necessary work to be performed in the remaining wings of the Laboratory.

LANGLEY RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

REHABILITATION AND MODIFICATION OF GAS DYNAMICS LABORATORY (1247)

SITE PLAN



Figure 2

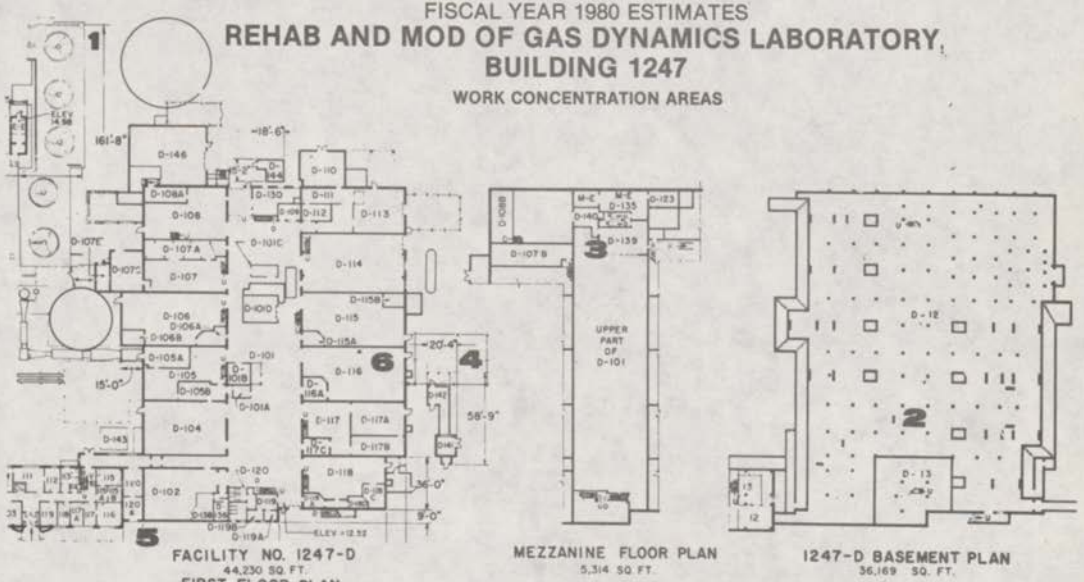
CF 5-30

LANGLEY RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

REHAB AND MOD OF GAS DYNAMICS LABORATORY, BUILDING 1247

WORK CONCENTRATION AREAS



FACILITY NO. 1247-D
44,230 SQ. FT.
FIRST FLOOR PLAN

MEZZANINE FLOOR PLAN
5,314 SQ. FT.

1247-D BASEMENT PLAN
36,169 SQ. FT.

LEGEND

1. REPAIR OF COOLING TOWERS
2. REHAB OF MECHANICAL EQUIP.
3. REHAB OF AIR CONTROL & DISTRIBUTION SYSTEMS
4. REHAB OF HIGH VOLTAGE ELECTRICAL EQUIPMENT
5. REHAB OF BLDG. 1247D
6. MOD OF DATA ACQUISITION SYSTEM

Figure 3

CF 5-31

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

SUMMARY

LEWIS RESEARCH CENTER

	Amount	Page No.
Office of Aeronautics and Space Technology:		
Modifications to Central Air System, Various Buildings.....	5,720,000	CF 6-1

LEWIS RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

MODIFICATIONS TO CENTRAL AIR SYSTEM, VARIOUS BUILDINGS

LOCATION PLAN

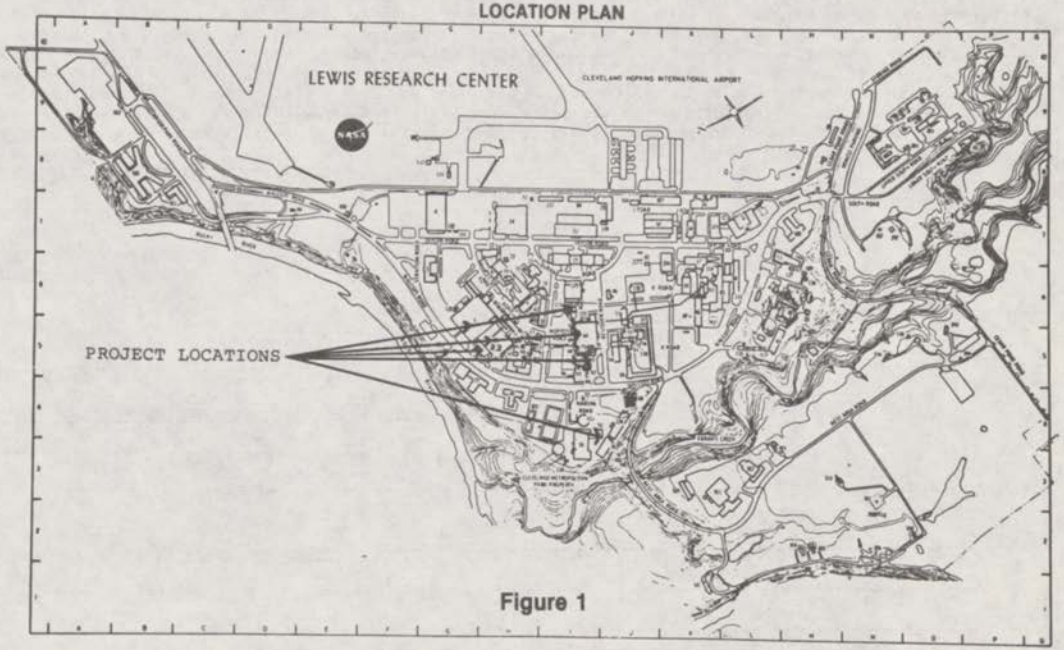


Figure 1

CF 6-1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE:	Modifications to Central Air System, Various Buildings
INSTALLATION:	Lewis Research Center
FY 1980 CoF ESTIMATE:	$5,720,000

LOCATION OF PROJECT: Cleveland, Cuyahoga County, Ohio

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Technology

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	711,000	450,000	1,258,000
Capitalized investment	N/A	41,084,000	41,084,000
Total	711,000	41,534,000	42,342,000

SUMMARY PURPOSE AND SCOPE:

Modifications to the Lewis Research Center (LeRC) Central Air System's 20 to 30-year old antiquated control and data acquisition systems are necessary to effectively meet the present and future aeronautical research program requirements. This air system, which is basic and critically essential to research activities at LeRC, contains a diversity of compressors, exhausters, drive motors, chillers, heaters, and other auxiliary equipment located primarily in the Propulsion Systems Laboratory Equipment Building (PSLEB), the Engine Research Building (ERB) complex, and related buildings and outdoor areas. Air at various pressures, temperatures, humidity levels, and flow rates, as well as exhaust capability at various vacuum levels and flow rates (for simulating altitude flight conditions) is provided to many research users through a complex piping distribution network

(Figures 4 and 5). The existing equipment controls are obsolete and have poor set-point tolerance and speed of response characteristics. These controls and the data acquisition systems for monitoring the Central Air System (CAS) operation are primarily manual and are located near noisy operating equipment throughout the various buildings and outdoor areas. This inefficient arrangement requires a large staff of equipment operators. Because of minimal equipment monitoring instrumentation, detection of abnormal operation is by surveillance of the actual operating equipment. Equipment operators, therefore, must be sufficiently experienced and familiar with the operating equipment to detect the onset of impending equipment failures.

This project provides for: (1) centralization and upgrading of the control and data acquisition systems for the equipment located in the PSLEB, Building 64, related Buildings 74, 95 and 124, and outdoor areas as well as construction of a new PSLEB control room addition (Figures 1, 2 and 3), and (2) installation of an ERB diagnostic "core" data acquisition system for determining the performance characteristics of the Roots-Connersville compressors and exhausters and other equipment in the ERB complex (Buildings 5, 23, and 37). As a result of this work: (1) operations will be not only more effective in meeting research needs, but will also require fewer and less experienced operators, (2) understanding of the operating equipment's performance characteristics and the overall CAS's capabilities will be improved which will result in significant energy savings, and (3) safety will be enhanced.

PROJECT JUSTIFICATION:

LeRC's 20 to 30-year old CAS, with its obsolete local controls and manual data monitoring techniques, provides compressed air and exhaust capabilities to numerous test cells and wind tunnels throughout the Center, serving over 100 different aeronautical, energy conservation and engine exhaust emission reduction research users. Usually, three-shift operations are such that an average of 23 research users are served each working day. Present and future research programs require closer control of system temperatures, pressures, and flow rates and faster transient response than the existing antiquated controls can provide. In addition, the available manpower is insufficient in quantity and experience to effectively meet research run schedules. This project provides for upgraded centralized remote control and monitoring of the equipment in and around the Propulsion Systems Laboratory (PSL) and also for centralized diagnostic monitoring of selected ERB equipment. The modifications will substantially improve the operational effectiveness and efficiency of the CAS while facilitating energy conservation, enabling full operations with a smaller and less experienced staff of equipment operators, and enhancing safety.

LeRC is a recognized leader in support of the Nation's aeronautical research programs. Many of LeRC programs require the use of the CAS for testing of propulsion systems (e.g., complete engines) and components (e.g., combustors, turbines, compressors, diffusers, and seals). Generally, aeronautical research programs fall into

the following two categories: (1) Cooperative NASA/Air Force - Full Scale Engine Research (FSER) and (2) NASA research programs for extending the state-of-the-art in both full scale engines and individual engine components. (Cooperative programs with the Air Force and Navy are being considered for this second category of research). The cooperative FSER programs use the large test cells. Current programs for pressure and temperature inlet air distortion, fan and compressor blade flutter, and improved engine performance controls use F100, J85-21, and TF30 test engines. NASA full scale engine research programs also use the large test cells and include research on plug nozzles, high frequency inlet distortion and afterburner rumble (low frequency instability). The High Pressure Turbine and Combustor Facility and numerous small test cells are delegated to engine component research for refinement of present engines and development of advanced engines including those with pressure ratios up to 40:1. The CAS provides conditioned air (dried and either heated or cooled) at 45, 150 or 450 psig (31, 103 or 310 newtons per square centimeter) to these test cells at various required research test conditions. This air is also exhausted from these test cells by the CAS at vacuum levels corresponding to the flight altitudes being simulated.

The present control and data acquisition systems consist of locally located manual controls and monitoring instruments widely distributed throughout 40,000 square feet (3,700 square meters) of the PSLEB, 175,000 square feet (16,300 square meters) of the ERB, related buildings and outdoor areas in noisy environments near the controlled equipment. Data logging is done manually. Present and future research requirements for air services supplied by the CAS, both during steady state and transient operation, are not attainable with the present antiquated controls. Research users have experienced long waiting periods for temperature set-point attainment and stabilization due to the present sluggish manual temperature controls. In addition, valuable research run time has been wasted due to pressure level perturbations resulting from pressure control instabilities. Monitoring instrumentation is minimal and equipment operators are relied on to detect indications of developing problems such as increased vibration levels, unusual noises and abnormal equipment operating temperatures by observation of the actual equipment. These ineffective and inefficient operations require a large number of experienced personnel familiar with the operating and general performance characteristics of the various pieces of equipment as well as the multitude of the CAS air routing possibilities. However, the staff of such operators is steadily diminishing and training of new operators is a long process requiring several years because of the complexity and size of the CAS. An additional 20 to 30 years of useful CAS equipment life is expected; however, the age of the equipment, the anticipated loss of experienced equipment operators, and the impact of major equipment failures on research activities make it increasingly important that continuous monitoring of critical equipment operating conditions be provided.

Accurate operating performance charts for much of the equipment are not available. When obtained for all equipment, these charts will provide a thorough understanding of the total CAS capability. Data obtained using

the data acquisition systems provided by this project and the PSLEB "core" data acquisition system provided by an FY 1978 project will enable more effective and energy efficient operations.

This project will result in an estimated annual energy savings of 14,000,000 kilowatt hours.

IMPACT OF DELAY:

These needed improvements are long overdue. Increased research requirements; decreased levels of experienced manpower; canceled research runs; lost run time; aging equipment; impact of major equipment failures; unreliable, inadequate, and obsolete controls; nonexistent, but necessary, monitoring and diagnostic instruments; limited energy budgets; manual data logging; and a need for more appropriate scheduling of equipment maintenance combine to form the pressing need for this work. These modifications must be accomplished to avoid these increasing operational limitations which impact the Center's overall research capability. The completion of the installation phase of this project is scheduled for early 1982 with the completion of the checkout phase by early 1983.

PROJECT DESCRIPTION:

This project includes the construction of a 4,500 gross square feet (418 gross square meters) control room addition to the PSLEB; the completion of the CAS control and data acquisition systems modifications in PSLEB, related buildings and outdoor areas started with a diagnostic "core" date acquisition system in FY 1978; and the installation of a diagnostic "core" data acquisition system for the Roots-Connersville compressors and exhausters and other equipment located in the ERB complex.

The new control room (Figure 2) will provide space for centralized remote control and monitoring of the CAS equipment located in PSLEB, related buildings and outdoor areas. Space is also provided for the future relocation of the central air dispatch (CAD) and electrical dispatch (ED) functions, as well as the utility control system (UCS) master control station.

This modification includes new equipment controllers with improved safety interlocks , a 3,000 channel, 12 remote multiplexer, data acquisition system and various new transducers to control and monitor air system parameters and equipment operating conditions including temperatures, pressures, flow rates vibration levels, valve positions, and other necessary subsystem data (Figure 3). In addition to highly responsive remote equipment controls, the operators in the control room will also be provided with: (1) immediate alarms for advance warning of potential problems, (2) hard copy printout capability for all channels (3) video (cathode ray tube) readout of selected flow system parameters and alarm channels, (4) fast, accurate, and continuously updated information on equipment operating conditions, and (5) long term trend information for more appropriate

maintenance scheduling. A dedicated minicomputer and necessary peripheral equipment are included for implementation of data acquisition and display as well as for supervisory control. Also included are miscellaneous pieces of equipment including valves and actuators for implementation of the control modifications.

The diagnostic "core" data acquisition system for the ERB Roots-Connersville compressors and exhausters and other equipment includes multiplexers, a dedicated mini-computer, transducers, and the necessary peripheral equipment. This "core" package provides for the monitoring of approximately 500 measurements and will operate independently with the present ERB equipment controls and data acquisition systems. This system will provide valuable operating performance charts for the equipment monitored.

This project will be implemented concurrent with the on-going CAS support of research operations. Proper scheduling of the installation work will result in minimal disruption of research activities.

This project includes work in the following facilities:

Bldg. No.	Name	Gross Area Sq. Ft.	Gross Area Sq. Meters	Year Built	Capitalized Investment
	Propulsion Systems Laboratory (PSL) Complex				
64	PSL Equipment Building	87,590	8,058	1952	21,000,000
74	PSL Cooling Tower Water Pump Building	4,702	433	1952	247,000
		1,024	94	1957	383,000
95	PSL Desiccant Air Dryer	5,680	523	1969	215,000
124	PSL Heater Building	98,996	9,108		21,845,000
TOTAL					
	Engine Research Building (ERB) Complex				
5	ERB (Central Section)	233,917	21,520	1942	14,100,000
23	ERB (West Wing)	104,246	9,684	1944	3,475,000
37	ERB (Northwest Wing)	35,010	3,221	1946	1,664,000
TOTAL		373,173	34,425		19,239,000

The replacement value of these facilities in terms of 1983 dollars will probably be about $300,000,000.

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PROJECT COST ESTIMATE:

The basis of this cost estimate is a Preliminary Engineering Report dated June 1978, and related studies.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	640,000
Demolition	LS	---	---	65,000
Architectural/structural modifications	SF	4,500	66.67	300,000
Mechanical modifications	LS	---	---	160,000
Electrical modifications	LS	---	---	115,000
Equipment	---	---	---	5,080,000
Controllers installation and integration	LS	---	---	1,220,000
Multiplexer system installation	LS	---	---	375,000
Transducers installation	LS	---	---	340,000
Data acquisition, display, minicomputer installation and integration	LS	---	---	2,470,000
Miscellaneous equipment installation	LS	---	---	175,000
ERB "Core" data acquisition system and integration	LS	---	---	500,000
Fallout Shelter (not feasible)	---	---	---	---
Total				5,720,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Plan View--New PSLEB Control Room
Figure 3 - Typical Configuration for Modification
Figure 4 - Schematic Drawing--Central Air System
Figure 5 - Aerial View of Piping Network

OTHER EQUIPMENT SUMMARY:

None.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

Future CoF funding of $7,000,000 will be required to: (1) complete the CAS control and data acquisition systems in the ERB, (2) relocate present central air dispatch (CAD) and electrical dispatch (ED) functions and the utility control system (UCS) master control station to the new PSLEB control room provided by this project, and (3) provide a new 450 psig air compressor and render the single aging 450 psig air compressor a standby. This follow-on work will complete the necessary modifications to the CAS.

LEWIS RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

MODIFICATIONS TO CENTRAL AIR SYSTEM, VARIOUS BUILDINGS

PLAN VIEW — NEW PSLEB CONTROL ROOM

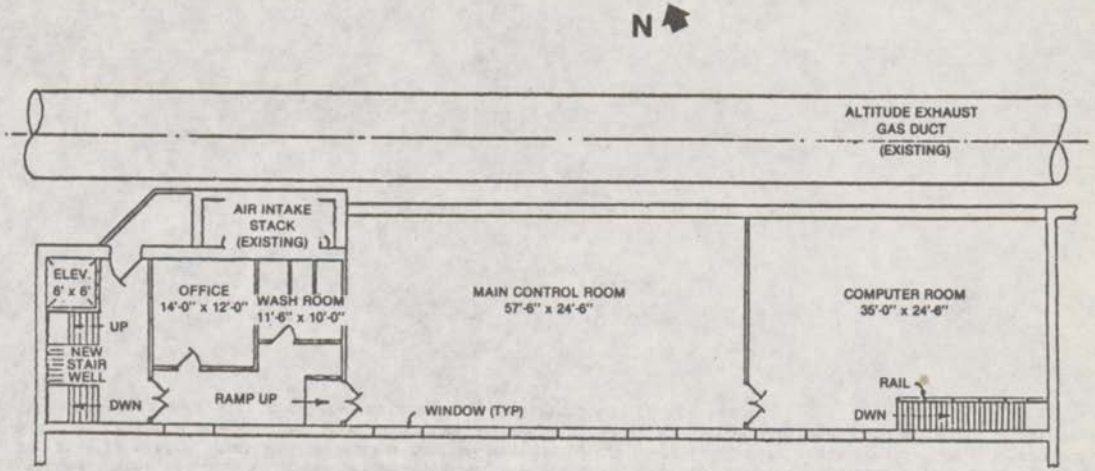


Figure 2

LEWIS RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

MODIFICATIONS TO CENTRAL AIR SYSTEM, VARIOUS BUILDINGS

TYPICAL CONFIGURATION FOR MODIFICATION

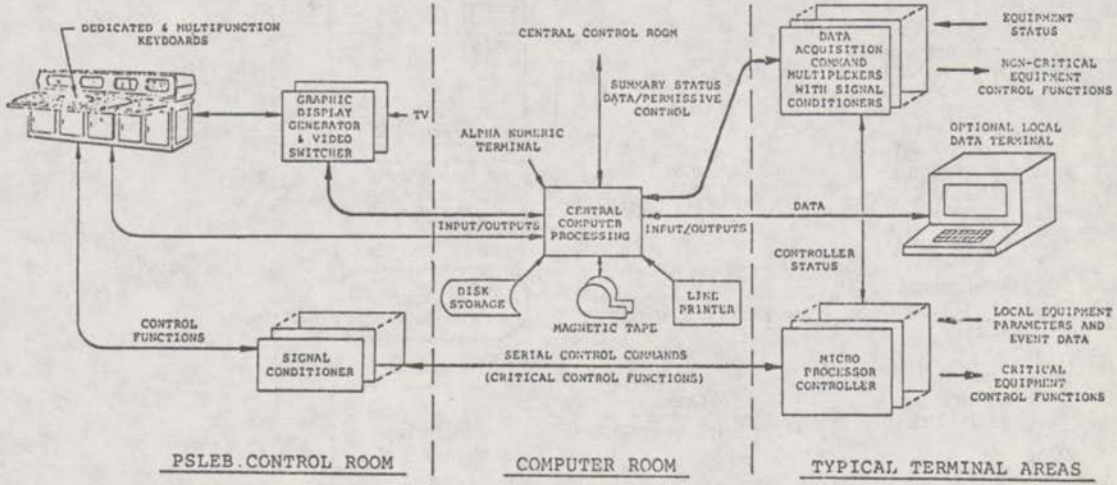


Figure 3

CF 6-11

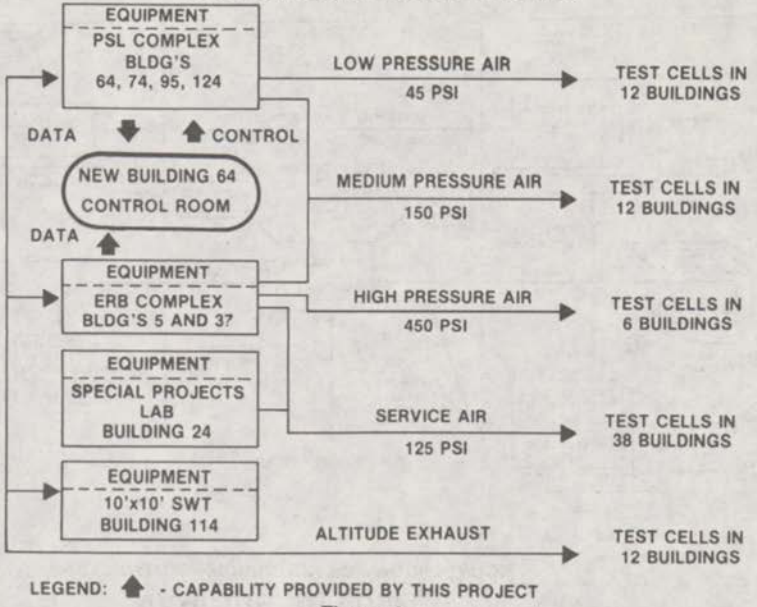
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LEWIS RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

MODIFICATIONS TO CENTRAL AIR SYSTEM, VARIOUS BUILDINGS

SCHEMATIC DRAWING - CENTRAL AIR SYSTEM



LEGEND: ⬆ - CAPABILITY PROVIDED BY THIS PROJECT

Figure 4

CF 6-12

LEWIS RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

MODIFICATIONS TO CENTRAL AIR SYSTEM, VARIOUS BUILDINGS

AERIAL VIEW OF PIPING NETWORK



Figure 5

CF 6-13

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

SUMMARY

GEORGE C. MARSHALL SPACE FLIGHT CENTER

Office of the Comptroller:	Amount	Page No.
Modifications to Various Buildings	2,640,000	CF 7-1
Rehabilitation of Roofs, Various Buildings	900,000	CF 7-10
Total	3,540,000	

MARSHALL SPACE FLIGHT CENTER
FISCAL YEAR 1980 ESTIMATES
MODIFICATIONS TO VARIOUS BUILDINGS

CF 7-1

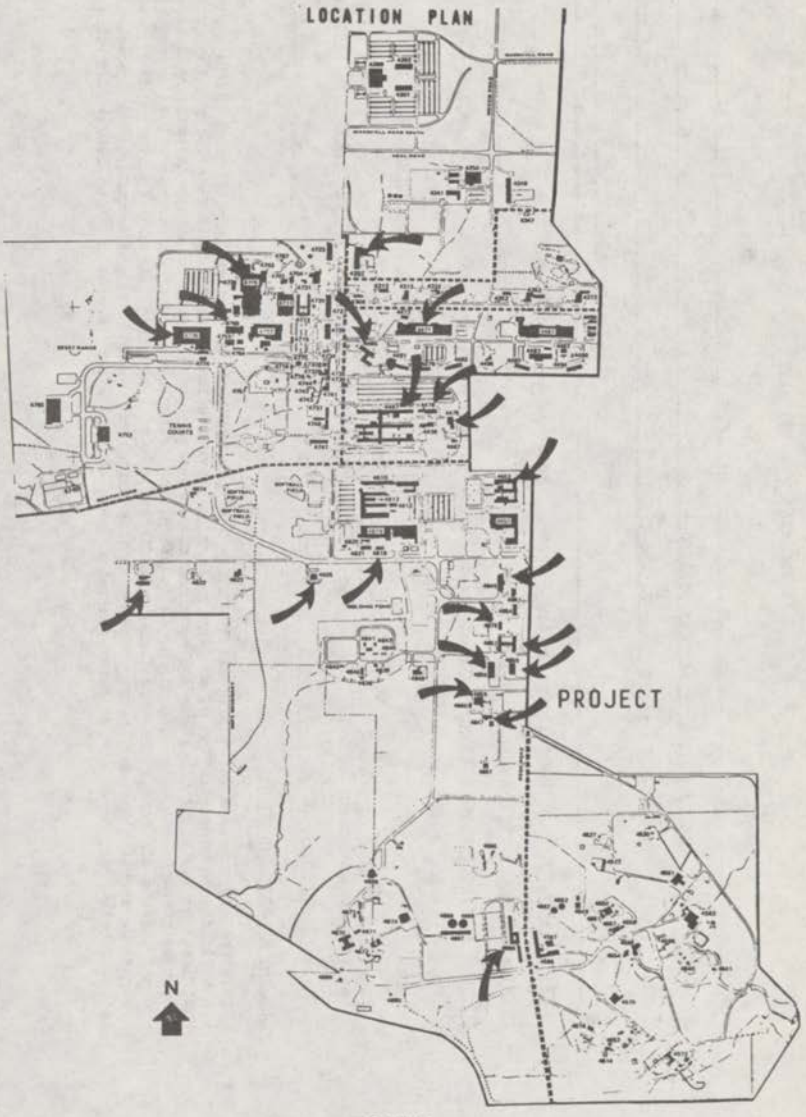


FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE: Modifications to Various Buildings

INSTALLATION: George C. Marshall Space Flight Center

FY 1980 CoF ESTIMATE: $2,640,000

LOCATION OF PROJECT: Marshall Space Flight Center, Madison County, Alabama

COGNIZANT HEADQUARTERS OFFICE: Office of the Comptroller, Facilities Division

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	131,000	---	131,000
Capitalized investment	N/A	39,408,258	39,408,258
Total	131,000	39,408,258	39,539,258

SUMMARY PURPOSE AND SCOPE:

This project provides for modifications to the heating, ventilating, and air-conditioning (HVAC) systems in ten buildings and installation of modular boilers in eleven buildings at Marshall Space Flight Center. Modifications to the HVAC systems are required to correct the deteriorated condition of existing systems, reduce maintenance costs, reduce energy consumption, and better accommodate Center operations in support of new and ongoing missions. The work includes modifications to fan drives, air distribution systems, control systems and lighting systems; repair of air-handling units; and installation of computer room process-cooling units, a heat pump to recover computer-generated heat, chilled water interconnections between buildings, and

additional building insulation. Modular boilers will be installed in eleven buildings, to serve thirteen buildings and replace the existing service supplied by the Redstone Arsenal Steam System (RASS). Eight of these buildings will go off the RASS permanently and five will go off the system in summer months only. Ten other buildings will have only hot water heaters installed and will similarly go off the steam distribution systems for the summer months. All of the RASS and most of the MSFC systems can be shutdown for approximately 6 months each year. This change is necessary due to the heavy heat losses experienced in these old long run steam lines.

PROJECT JUSTIFICATION:

MSFC is directing efforts in a planned reduction of energy consumption and this project is a necessary step in this reduction. It provides for the complete modification of systems to reduce energy consumption and maintenance costs. Utility rates have increased approximately 125 percent in the last 3 years, and trends indicate similar increases in the near future. Maintenance forces continue to decline and related material costs continue to inflate. Delay in accomplishing the work included in this project will not allow the Center to substantially reduce energy consumption; it hampers support to important Center programs and other research and development activities. These buildings are and will continue to be utilized in providing direct support to many NASA programs, such as Space Shuttle, Spacelab, Space Telescope, Space Processing, Large Space Structures, Solar Heating and Cooling, and Space Research and Technology. Accordingly, these modifications are required not only to conserve energy but also to provide the working environment necessary to support these programs.

The age of these facilities range from 14 to 35 years, with the average age of 23 years. Many changes and minor additions have been required and they, coupled with age, have contributed to overloading and unbalancing of the utility and mechanical systems. As a result, the building systems require extensive maintenance and also use excessive amounts of energy. The HVAC systems have required extensive piecemeal modifications. They should be properly rehabilitated and the systems modernized and rebalanced for greater reliability and energy conservation.

MSFC "inherited" the existing steam distribution system from the Redstone Arsenal when the Center became activated in 1960. Though the arsenal still generates the steam and operates the system, the steam is metered as it crosses the boundary and NASA is billed accordingly. Through a series of studies and site investigations, it has been determined that the steam line losses are abnormally high, especially due to long line runs, thus MSFC is being subjected to excessive steam energy costs. The buildings in which the modular boilers and water heaters are to be installed to replace the steam lines, are widely dispersed. The boiler and water heater installations are considered to be more economical than repairing or replacing the steam lines. Six of the buildings will be taken completely off the steam system, resulting in the deactivation of 24,000 linear feet (7,315 meters) of steam supply and return lines. The other five buildings will be taken off the system during

the summer months only. In this latter case, the boilers will be sized and used for summer reheat, potable hot water, and process steam requirements only, but not for winter heating. In addition to these five buildings, ten additional buildings will have only electric heaters installed and will also be taken off the steam distribution system during the summer months. These facilities are required to support ongoing and planned programs at the Center. Activities performed at these facilities include: non-destructive evaluation of materials, hydraulic component and system testing, low temperature and cryogenic testing, high-pressure gas systems, control actuator development, gaseous nitrogen generation, and treatment of industrial waste. These activities support all currently assigned programs and will be similarly used to support future programs assigned to the Center. This project will permit the periodic and/or complete deactivation of steam lines for which heat losses have been excessive.

The total project will result in an estimated saving in energy costs of over $750,000/year during the first year of operation with a simple payback of approximately 3.5 years for the total investment.

IMPACT OF DELAY:

As previously described, this project has a very attractive energy savings and good payback savings. Failure to implement the project at this time will not allow these savings to be made and will prolong a high energy consumption/high utility cost situation.

PROJECT DESCRIPTION:

This project provides for modifications to HVAC systems in various buildings at MSFC. Work in Building 4705 (Fabrication and Machine Shop) will include the modifications to heating system controls to permit shutting off steam circulation in accordance with area demands, rehabilitating the HVAC system to permit maximum outside air intake capability, converting controls to demand system, reducing air velocity in the system and reducing the lighting system to current illumination guidelines.

Buildings 4475 (Hazardous Operations Laboratory) and 4476 (Environmental Test Facility) will have the chilled water systems modified by extending the chilled water distribution piping from Building 4487 to replace 2 chillers (90- and 100-tons) in these two buildings, thereby eliminating the need for replacement of the two units. The Building 4487 system can easily handle the extra load from capacity provided for earlier programs.

Modifications to Buildings 4207 (Communications Facility), 4485, 4666 (Office Buildings), and 4708 (Engineering and Development Laboratory) will include the installation of time clock systems for the start/stop of HVAC systems, conversion to a Variable Air Volume (VAV) System, revision of controls from set point to demand, and elimination of redundant overhead systems and bypasses.

The five air-handling units on the west end of Building 4471 (Storage and Office Building) will be removed from above the ceiling, and one new unit will be installed at floor level. The system will be converted to an economizer cycle, utilizing outside air for cooling when appropriate, thereby permitting shutdown of the Central Water Chiller during the winter months.

The project also provides for modifications to Building 4487 (Laboratory and Office Buiding) computer room HVAC systems. The work will include segregation of computer rooms from adjacent offices and conference rooms to permit better use of demand capability, and modifications to make computer waste heat available for heating the building.

Modifications to the HVAC systems in Building 4663 (Computer Facility) will include replacing 40 obsolete, deteriorated air-handling units with 11 new chilled water type and 21 chilled water, process-cooling units designed for use in computer room application by making maximum use of computer-generated heat.

Modular boilers will be installed in Buildings 4605 (Non-destruction Evaluation Lab), 4618 (Hydraulic Test Facility), 4628 (Cryogenic Testing Facility), 4647 (Compressor Building), 4649 (Multi-purpose High Bay Facility), 4656 (Hydraulic Equipment Development Facility), 4659 (High Pressure GN_2 Facility), and 4678 (Office and Storage Building) to meet year-round steam/heating requirements. All valving necessary to permit cutting off the existing steam supply to the buildings will also be included, as will the necessary electrical and water connections to the new boilers. Both electrical and oil-fired boilers will be analyzed during the design phase to determine the most economical system in terms of initial and life-cycle costs, as well as fossil fuel consumption.

This project also provides for the installation of modular boilers in Buildings 4487 (Laboratory and Office Building), 4663 (Computer Facility), 4760 (Surface Treatment Facility), 4705 (Fabrication and Machine Shop) and 4706 (Neutral Buoyancy Simulator) to fulfill the building requirements for summer reheat, potable hot water, and process steam. The work includes connections to existing supply and condensate return lines where required for all five buildings. Both electric and oil-fired boilers are to be considered during the design phase in terms of initial and life-cycle costs, and fossil fuel consumption.

For further conservation of heat energy, electric hot water heaters will be installed in ten buildings where only reheat and/or potable hot water are required and the buildings will be removed from the distribution systems during the summer months. Installation of these modular boilers and hot water heaters will permit complete shutdown of the RASS and some 60-75 percent of the MSFC systems.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	2,640,000
HVAC modifications	---	---	---	2,035,000
Building 4705, Fabrication and Machine Shop	LS	---	---	(310,000)
Building 4475, Hazardous Operations Facility	LS	---	---	(50,000)
Building 4476, Environmental Test Facility	LS	---	---	(30,000)
Building 4207, Communications Facility	LS	---	---	(25,000)
Building 4485, Office Building	LS	---	---	(15,000)
Building 4666, Office Building	LS	---	---	(95,000)
Building 4708, Engineering & Development Laboratory	LS	---	---	(190,000)
Building 4471, Storage and Office Building	LS	---	---	(90,000)
Building 4487, Laboratory and Office Building	LS	---	---	(220,000)
Building 4663, Computer Facility	LS	---	---	(1,010,000)
Installation of modular boilers and water heaters	---	---	---	605,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				2,640,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Economizer Cycle
Figure 3 - Typical Timer Control of HVAC Units

OTHER EQUIPMENT SUMMARY:

There is no other equipment required to be used with this facility project.

FUTURE CoF ESTIMATED FUNDING TO COMPLETE THIS PROJECT:

No future CoF funding is anticipated for this project.

MARSHALL SPACE FLIGHT CENTER
FISCAL YEAR 1980 ESTIMATES
MODIFICATIONS TO VARIOUS BUILDINGS. ECONOMIZER CYCLE

CF 7-8

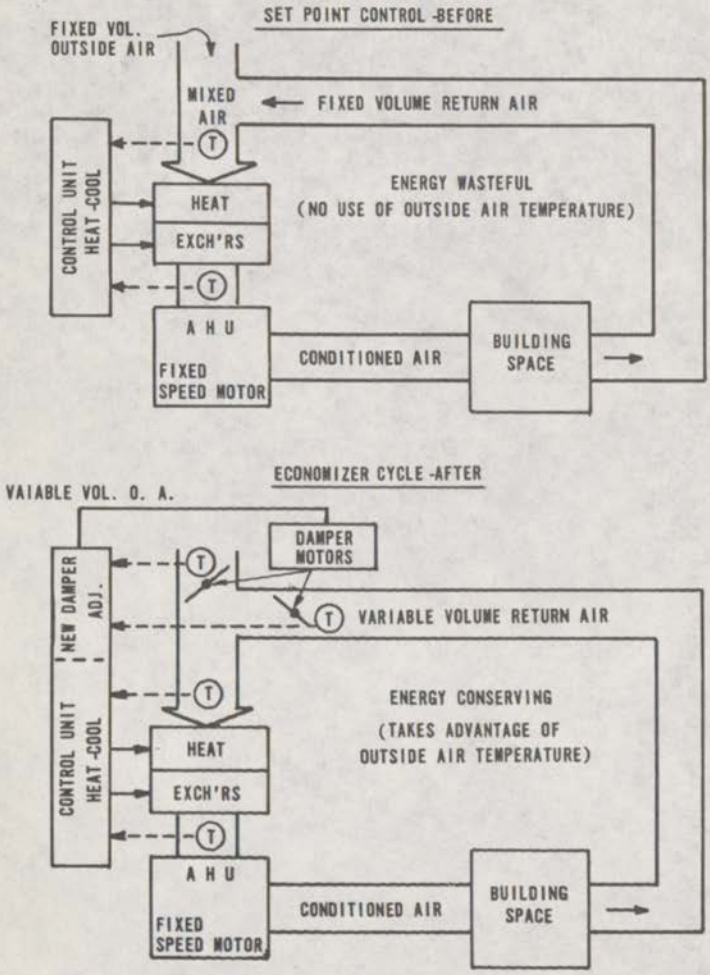


FIGURE 2

MARSHALL SPACE FLIGHT CENTER
FISCAL YEAR 1980 ESTIMATES
MODIFICATIONS TO VARIOUS BUILDINGS
TYPICAL TIMER CONTROL OF HVAC UNITS

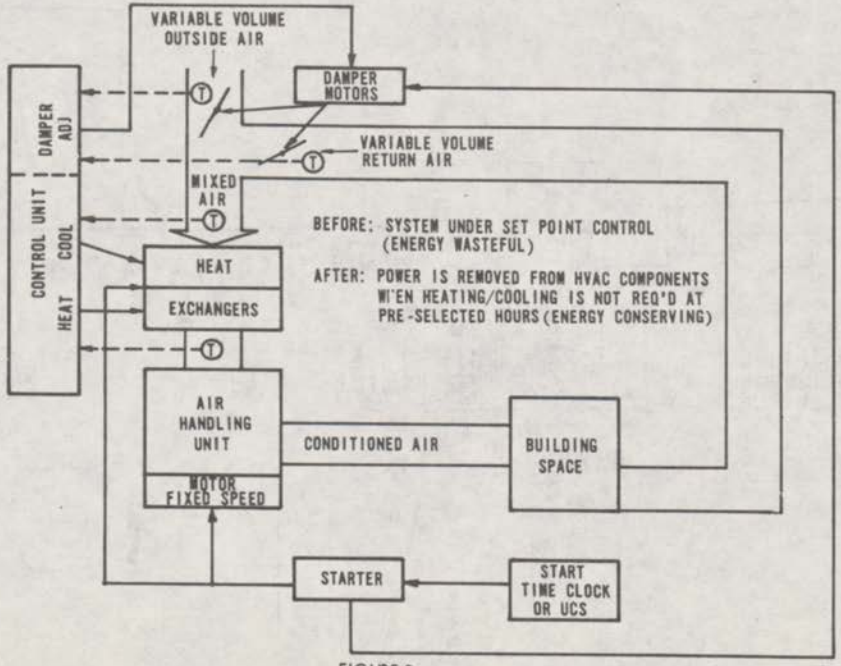


FIGURE 3

CF 7-9

43-843 O - 79 - 40

MARSHALL SPACE FLIGHT CENTER
FISCAL YEAR 1980 ESTIMATES
MODIFICATIONS OF ROOFS, VARIOUS BUILDINGS

CF 7-10

LOCATION PLAN

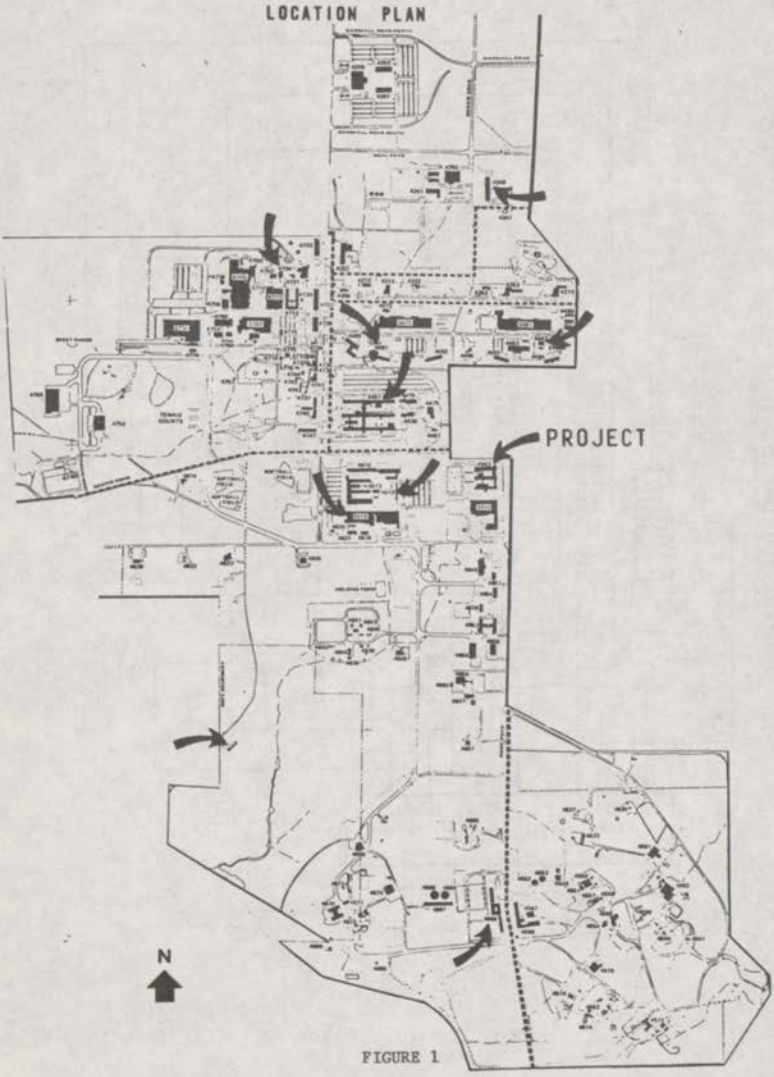


FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE: Rehabilitation of Roofs, Various Buildings

INSTALLATION: George C. Marshall Space Flight Center

FY 1980 CoF ESTIMATE: $900,000

LOCATION OF PROJECT: Marshall Space Flight Center, Madison County, Alabama

COGNIZANT HEADQUARTERS OFFICE: Office of the Comptroller, Facilities Division

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	44,000	---	44,000
Capitalized investment	N/A	29,377,506	29,377,506
Total	44,000	29,377,506	29,421,506

SUMMARY PURPOSE AND SCOPE:

This project provides for the rehabilitation of the roofs of ten major buildings at Marshall Space Flight Center (Figure 1), by the replacement and/or repair of approximately 1700 squares of roofing (a square is 100 square feet). The proposed work includes selected roof portions of Buildings 4249, 4482, 4487, 4491, 4612, 4619, 4663, 4666, 4697, and 4704. Work is required to rectify blistering, soft spots, drying-out, and alligatoring of roof surfaces. This calls for the replacement of roofing, insulation and damaged flashing. This rehabilitation will correct the deteriorated condition of the building roofs, reduce maintenance costs, and eliminate the possibility of damage to ceilings, floor, light fixtures, and equipment.

PROJECT JUSTIFICATION:

The rehabilitation of roofs is essential to protect and preserve facility capability and to remove the threat of unscheduled interruption to the Center's research operations. By 1980, the roof age of these facilities will range from 15 to 37 years, with the average being 22 years. Normal roof lifetime in this geographic area is 15 years or about and, consequently, these roofs have served a normally expected life span. Higher priority mission-related needs coupled with limited resources have resulted in the need to progressively defer major roof maintenance work for the last three years and this has added to the ultimate urgency of doing this work now. The roofs in this project have been continuously patched many times in the past 15 years and in many areas the patches have been repatched. As a result, the maintenance cost is increasing each year. This project will provide for the refurbishment of the roofs to protect the building structural integrity and prevent possible damage which could cost several times the cost of the roof repairs. Many areas on the roofs are soft and spongy, indicating a breakdown of the insulation. Once roof insulation is saturated with water, it must be replaced. Imminent danger of roof failure is clearly demonstrated by blisters, soft spots, air pockets, and cracked and dried out areas. Roofs in this condition must be repaired or replaced as soon as possible to preclude damage to building structures, ceilings, light fixtures, and sensitive electronic equipment. Counter flashing, roof vents, gutters and downspouts are rusted or in bad condition and need replacement on some of the buildings listed. The buildings included in this project represent some 797,000 square feet (74,000 square meters) of office, laboratory, and shop space, or approximately 22 percent of MSFC's inventory of active usable space.

IMPACT OF DELAY:

Delay of repairing the roofs requested in this project will subject the buildings to damage from water leakage. Damage that could occur would vary from building damage, to serious damage to valuable R&D equipment. Delay will also make it necessary to continue less effective and economical efforts to patch on a wider basis.

PROJECT DESCRIPTION:

This project addresses the rehabilitation of approximately 1700 squares of roof area. The buildings selected have been determined to be those in greatest need of repair. Approximately 1200 squares of roofing on 7 buildings will be repaired by replacing gravel guard foam glass insulation, counter flashing, cants, nailers, and 5-ply built-up roofing. Approximately 450 squares of 5-ply built-up roofing only will be installed on 2 buildings. Building 4704 has a 50-square corrugated metal roof, which will be repaired by spraying two coats of black emulsion sealer and one finish application of aluminum coating. All roofs will have a smooth silver-gray finish to reflect solar heat as an energy conservation measure. Roof drains, gutters, and downspouts will be realigned and replaced as required.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	900,000
Replace roofing, cants and nailers	SQ	1,650	409.82	676,200
Replace insulation	SQ	1,200	50.92	61,100
Roof coating	SQ	50	114.00	5,700
Replace sheet metal and drains	LS	---	---	157,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				900,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan

OTHER EQUIPMENT SUMMARY:

No other equipment is required.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

It is anticipated that an average of about $700,000 per year over the following four years will be required to "catch up" so that a normal maintenance program can be effective until the next cycle of major rehabilitation is needed.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

SUMMARY

WALLOPS FLIGHT CENTER

	Amount	Page No.
Office of the Comptroller:		
Construction of Facilities Operations Shop Building.....	1,100,000	CF 8-1

WALLOPS FLIGHT CENTER

FISCAL YEAR 1980 ESTIMATES

CONSTRUCTION OF FACILITIES OPERATIONS SHOP BUILDING

LOCATION/SITE PLAN

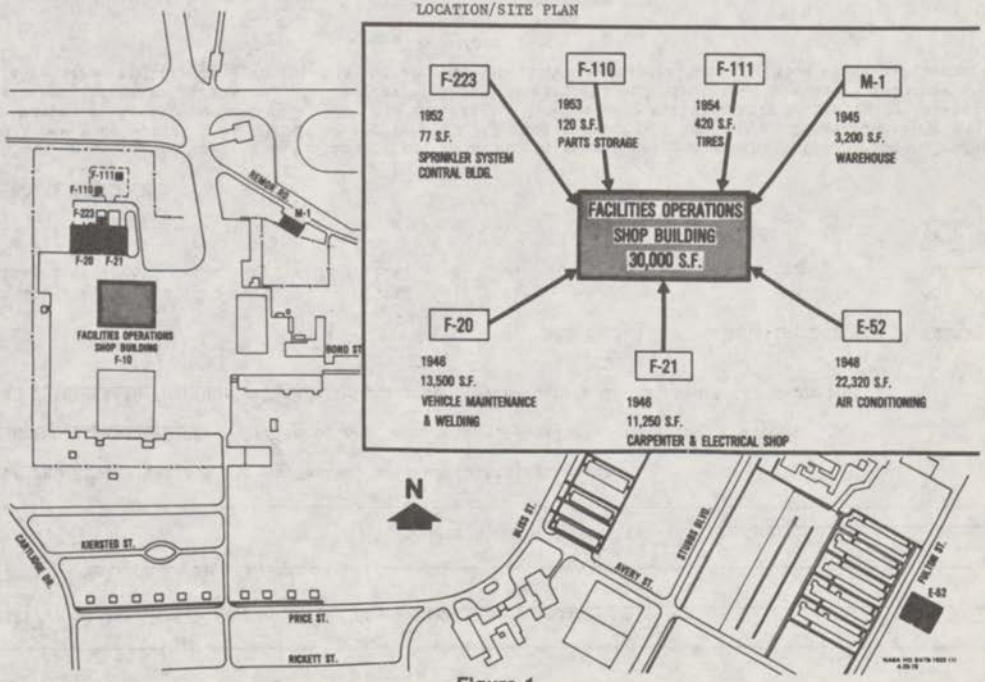


Figure 1

CF 8-1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE:	Construction of Facilities Operations Shop Building
INSTALLATION:	Wallops Flight Center
	FY 1980 CoF ESTIMATE: $1,100,000

LOCATION OF PROJECT: Wallops Flight Center, Wallops Island, Virginia

COGNIZANT HEADQUARTERS OFFICE: Office of the Comptroller, Facilities Division

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	95,000	---	95,000
Capitalized investment	N/A	---	---
Total	95,000	---	95,000

SUMMARY PURPOSE AND SCOPE:

This project provides for the consolidation of the maintenance shop functions at the Wallops Flight Center (WFC) into a new shop building of 30,000 square feet (2,787 square meters) (Figure 1). These functions are presently located in seven substandard 30-year old buildings. The new shop building will be centrally located, of pre-engineered steel construction, with energy efficient mechanical and electrical systems. This new facility is required at this time to improve the working conditions and operations of these vital maintenance functions.

PROJECT JUSTIFICATION:

This project will consolidate the Center's maintenance functions from seven old, substandard buildings into a new centrally located shop building. The seven buildings are scattered over a distance of 3,000 feet (914 meters), are beyond economical rehabilitation and will be demolished. This consolidation is the result of a utilization study of the existing facilities which examined several options and was directed towards more economical operations. The consolidation of the Facilities Operations Branch will result in a reduction of energy consumption, permit better utilization of available equipment and personnel, and provide an improved level of maintenance support. The new shop facility will provide space for 85 people in the vehicle maintenance, electrical, carpentry, utility, and air conditioning shops, and for the branch office (Figure 2).

This project is needed at this time to permit the demolition of buildings which are beyond their useful lives, improve working conditions and operations, save energy, and provide better maintenance support with the available manpower.

IMPACT OF DELAY:

The delay in providing for these vital research support facilities will involve the continuation of very unsatisfactory conditions and the probable expenditure of resources on old facilities with limited results.

PROJECT DESCRIPTION:

This project provides for the construction of a 30,000-square foot (2,787 square meter) pre-engineered steel building with insulated wall and roof panels. The building will be located near the Technical Service Shops and Office, Building F-10, on an existing concrete apron. Electrical, steam, water, and sanitary services will be extended to the building. Shop space will be provided for: vehicle maintenance of 11,000 square feet (1,022 square meters), electrical of 4,000 square feet (372 square meters), carpentry of 4,000 square feet (372 square meters), utility of 4,000 square feet (372 square meters), air conditioning of 4,200 square feet (380 square meters), and others. Operable vehicle access doors, parts and tool storage space will be provided for each shop space. Suitable electric power, lighting, installed shop equipment, heating and ventilation will be provided. In addition, locker room facilities and air conditioned mezzanine-level office space of 1,500 square feet (139 square meters) will be included. Appropriate safety and fire protection systems will be installed in the building.

This work also includes the demolition and site restoration of Buildings E-52, F-20, F-21, F-110, F-111, F-223, and M-1.

PROJECT COST ESTIMATE:

The basis of this cost estimate is a Preliminary Engineering Report.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	920,000
Utilities (outside 5' line)	LS	---	---	50,000
Architectural	SF	30,000	19.67	590,000
Plumbing	SF	30,000	1.67	50,000
HVAC	SF	30,000	3.67	110,000
Electrical	SF	30,000	4.00	120,000
Equipment	LS	---	---	70,000
Demolition and Site Restoration	SF	50,000	2.20	110,000
Fallout Shelter (not feasible)	---	---	---	---
Total				1,100,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location/Site Plan
Figure 2 - Floor Plan

OTHER EQUIPMENT SUMMARY:

There is no other equipment required to be used with this facility project.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THE PROJECT:

No further funding is anticipated for this project at this time.

WALLOPS FLIGHT CENTER

FISCAL YEAR 1980 ESTIMATES

CONSTRUCTION OF FACILITIES OPERATIONS SHOP BUILDING

FLOOR PLAN

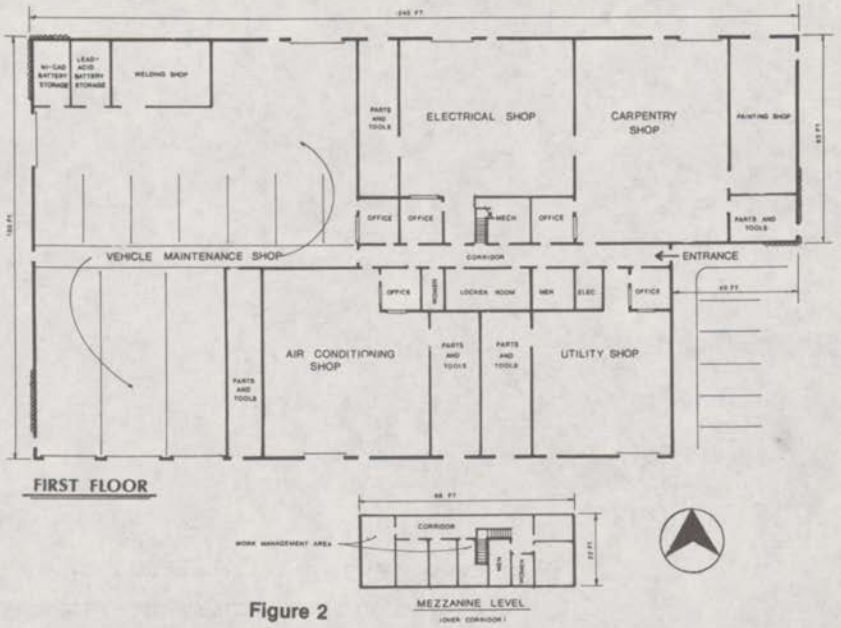


Figure 2

CF 8-6

CNATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

SUMMARY

LARGE AERONAUTICAL FACILITIES

	Amount	Page No.
Office of Aeronautics and Space Technology:		
Construction of national transonic facility (LaRC)	12,000,000	CF 9-1
Modification of 40- by 80-foot subsonic wind tunnel (ARC)	33,900,000	CF 9-21
Total	45,900,000	

LANGLEY RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES

CONSTRUCTION OF NATIONAL TRANSONIC FACILITY
LOCATION PLAN

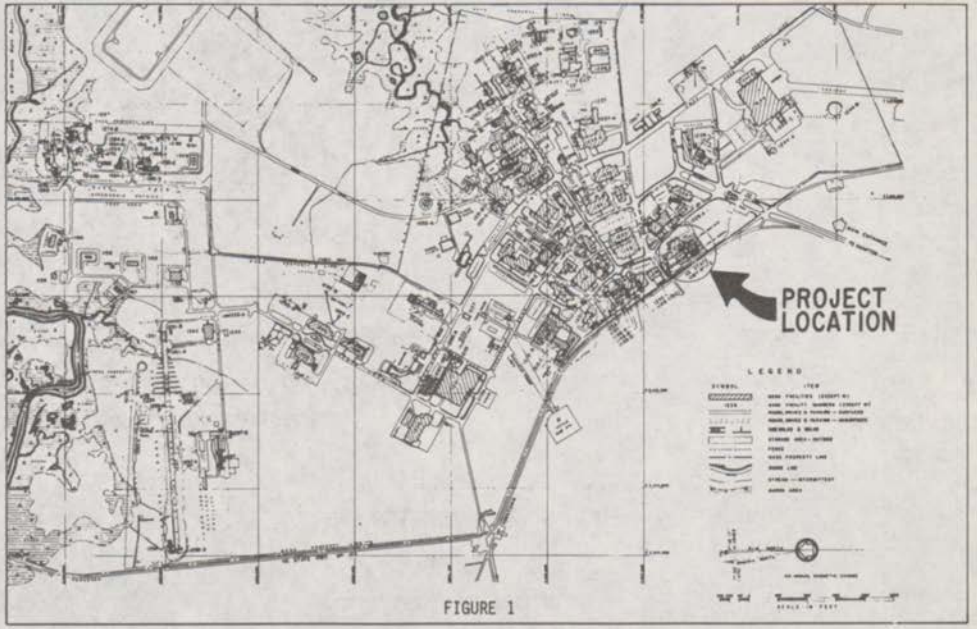


FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE:	Construction of National Transonic Facility
INSTALLATION:	Langley Research Center
FY 1980 CoF ESTIMATE:	$12,000,000

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Technology

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	7,850,000	73,000,000	80,850,000
Capitalized investment	N/A	4,942,000	4,942,000
Total	7,850,000	77,942,000	85,792,000

SUMMARY PURPOSE AND SCOPE:

Construction of the National Transonic Facility (NTF) at Langley Research Center (Figure 1), began with FY 1977 funding, was continued with FY 1978 and FY 1979 funding, and will be completed with this requested funding. This facility, a transonic wind tunnel which will serve the research needs of NASA and the development testing needs of DOD and the aerospace industry, will provide a totally new and vital capability to test a broad spectrum of aeronautical vehicles, including civil, commercial, military, as well as space vehicles, at full-scale Reynolds numbers. It will employ a cryogenic test medium for achieving high Reynolds numbers without excessive model loads or power requirements. This will involve injection and subsequent evaporation of liquid

nitrogen to develop the extremely low temperature test medium in an otherwise conventional fan-driven closed circuit wind tunnel. With temperature, pressure and speed independently controlled, the facility will permit clear separation of aeroelastic, Mach number and Reynolds number effects on the aerodynamic performance of test configurations. The capability to separate these effects has heretofore been unattainable in ground facilities. Thus, when completed, the new tunnel will provide an entirely new realm of research capability geared not only to Reynolds numbers, but also to the ability to investigate other significant aerodynamic parameters independently of one another.

Funding requested for FY 1980 will be used to complete both the fabrication of the tunnel structural components and their installation. It will also provide for continuation of work on the tunnel drive system and it will support the beginning of construction on all of the remaining NTF work packages.

The relationship of the FY 1977, FY 1978, FY 1979, and FY 1980 funding requirements is summarized in Figure 11.

Analysis of project schedules and project management capabilities indicate that scheduling resources in several consecutive years, as is done for this project, will not adversely affect the operational schedule for this large facility. At present, the NTF is expected to be operational in the latter half of 1982. Most of the preliminary engineering, special studies and design have been completed, and actual construction was initiated in late 1976.

PROJECT JUSTIFICATION:

World leadership in aircraft design and the superiority of U.S. military flight vehicles are heavily dependent upon ongoing research and new technology. In recent years, an urgent need has developed for several new ground facilities for aerodynamic testing at transonic speeds and at flight Reynolds numbers. This need is supported by the Department of Defense, the U.S. aerospace community, and by the North Atlantic Treaty Organization Advisory Group for Aerospace Research and Development (AGARD). In spite of spectacular advances in aerodynamics during the last 20 years, a number of leading aircraft developments have encountered difficulty because of misleading or inadequate wind tunnel testing data in the transonic regime. Experimental data obtained from existing low Reynolds number transonic wind tunnels often are inadequate to predict flight vehicle performance. This is because a vehicle traveling at transonic speed experiences supersonic air flow velocities over portions of its surface area, thereby leading to unsteady flow conditions where Reynolds number sensitive shock/boundary layer interaction effects occur. While the transonic flight environment is common to a broad spectrum of flight vehicles--such as civil, commercial, military, and space--this "Reynolds number sensitive"

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aerodynamic environment generally is difficult to study analytically and thus, accurate experimental data at or near flight Reynolds numbers are required for an adequate solution.

A wind tunnel permitting accurate experimental measurement at transonic speeds approaching flight Reynolds numbers is therefore necessary for the continuing development of new technology. This will allow increases in the efficiency, performance, size and range of civil and military aircraft. Thus, the urgency of the new testing capability suggests that this facility be completed at the earliest possible time.

When operational, the NTF will provide the test capability to meet the high Reynolds number, transonic speed regime technology development requirements of NASA, DOD and industry. Current planning indicates that NASA programs will use approximately 40 percent of the available test time, DOD 40 percent also, and industry 20 percent. To meet these program needs, the tunnel will be operated on a two-shift basis. Approximately 75 percent of the NTF operation will be conducted using the cryogenic test medium, consuming on the order of 90-120 thousand tons of liquid nitrogen per year.

The capability to simulate full-scale Reynolds numbers on a model in a wind tunnel at Mach numbers near 1.0 requires a workable test section size of 8.2 x 8.2-feet (2.5 x 2.5 meters) with a maximum operating pressure of about 130 psi (896,000 newtons per square meter). It also requires run times long enough to permit accurate data measurements in all areas of aerodynamic research. The quality of the test flow should be of the highest practical level. There are no known wind tunnels in the United States or Europe that will satisfy these requirements. The need for an aeronautical test facility with these capabilities was confirmed in FY 1977, FY 1978 and again in FY 1979, in which years $25 million, $23.5 million, and $24 million, respectively, were made available for construction of the NTF. The FY 1980 request is for resources to complete work already begun on this facility.

IMPACT OF DELAY:

The need for significantly improved ground test capability of aerodynamic configurations in the high Reynolds number, transonic flight regime has been validated and fully supported by prior years resources availability. With this request, the fourth for this multiyear funded project, construction can proceed to completion as scheduled in an orderly and business-like fashion. Delay would not only impact scheduled completion but also it would greatly impact total ultimate cost of this facility. A number of contracts, started with prior years resources, will be completed with these requested funds. Delay would require the lengthening of the schedules for these particular contracts at an increased cost to the government. Also, such delay would affect other contracts which interface with the directly impacted work packages.

PROJECT DESCRIPTION:

FY 1980 resources will provide the fourth sequential funding element for the construction of a fan-driven, closed circuit wind tunnel as shown in Figure 4. It will be 200 feet (61 meters) long, 48 feet (14.6 meters) wide, will vary in diameter from 40 feet (12.2 meters) to 11 feet (3.4 meters), and will have an operating pressure range from 14.7 psi (101,400 newtons per square meter) to a maximum of 130 psi (896,000 newtons per square meter) and an operating temperature range from 155°F to -300°F (341.5°K to 88.7°K). Cryogenic temperatures will be obtained by evaporating liquid nitrogen that has been injected into the tunnel circuit. The cryogenic approach is now the most effective energy conserving technique for achieving high Reynolds numbers without excessive model loads. The tunnel pressure shell will be fabricated from stainless steel and will be insulated internally to contain the cold gas. A fixed-pitch single-stage fan will drive the tunnel air flow through an 8.2 x 8.2-Foot (2.5 x 2.5 meters) slotted test section to produce Mach numbers ranging from 0.2 to 1.2. The Mach number range is obtained through the use of variable speed motors and variable inlet guide vanes.

A three-dimensional model support system (Figures 5 and 6), having an angle of attack range of 30 degrees, will be installed in the test region. Viewing ports in the walls of the slotted test section will be provided for remote television viewing of the model under test.

The NTF is being constructed on the site of the recently demolished 4x4-Foot (1.2 x 1.2 meters) Supersonic Wind Tunnel (4-Foot SWT) (Figure 2) and will incorporate the electric motor drive system of that tunnel. These two motors, which will provide approximately half the total operating power required, have a combined rating of 47,000 HP (35,062 KW) for continuous duty. They are capable of 70,000 HP (52,220 KW) for run times up to 10 minutes. A two-speed gear system (Figure 7) will be provided to match the fan with motors at both ambient and the full-range of cryogenic temperatures. A speed control system will be provided to achieve a constant torque from the motor over a wide range of revolutions per minute to improve the power characteristics of the motors for this new application. A new 60,000 HP synchronous drive motor (44,760 KW) (10 minute rating) will be installed to provide the additional power required to achieve the greater pressure needed to obtain higher Reynolds numbers. The facility will use the existing cooling tower, pumps, auxiliary equipment and buildings. A new two-story shop addition (Figure 3) of approximately 33,500 square feet (3,112 square meters) will accommodate the larger transonic test section. The shop will include space for a control and data acquisition room, and for an improved model preparation area. Adequate controls, process monitors, and data acquisition systems are included in this project.

A liquid nitrogen storage and supply system will accommodate nitrogen flows to the tunnel at rates up to about 1,000 pounds per second (454 kg per second). This is required to remove the heat generated by the fan

during constant cryogenic temperature operation. Additionally, a pressure control and venting system is provided to maintain constant pressure during data gathering. The vent will feed into an exhaust stack acoustically designed to satisfy environmental standards.

Both the design and construction of this project are being managed on a "work package" basis. Each of the "work packages" contains all elements of work to be accomplished through separate procurement, scheduling, and cost control. This approach is particularly effective for an extremely complex facility such as this because it results in better project management, improved competition, and better functional and cost-effective designs.

FY 1977 funding provided for the demolition and removal of nonreusable portions of a 4x4-Foot (1.2 x 1.2 meters) Supersonic Wind Tunnel (located on the NTF site). It also provided for the driving of piles and construction of virtually all foundations required for the new tunnel, as well as the first increment of the tunnel pressure shell fabrication and erection. Additionally, initial funding provided for the first increment of the new drive system and fan components.

FY 1978 funding provided for completion of the foundations, continuation of the tunnel pressure shell fabrication and erection, purchase of the tunnel insulation and liner, and construction of the liquid nitrogen storage system. It also provided for the start of work on the tunnel structure components fabrication and the special piping system. The second funding element permitted continuation of work on the tunnel drive system and fabrication of the model support system. Fabrication of the drive shaft and disk has been completed and these major components have been shipped to the drive system fabricator.

FY 1979 funding provided for the completion of the tunnel pressure shell fabrication and erection (Figures 3, 9 and 10) and initiation of the tunnel structure internal components fabrication (Figure 8). The tunnel pressure shell will form the general aerodynamic shape of the tunnel circuit and is being built of rolled and welded stainless steel plate and forgings designed to withstand the extreme temperature and pressure fluctuations that will occur during actual tunnel operations. Foundations for the tunnel pressure shell have been completed and considerable progress has been made in fabrication of the pressure shell. The tunnel structure internal components, to be fabricated of aluminum, will define the actual flow boundaries in the test section and fan region. FY 1979 resources are also being used to start installation of these complex and difficult-to-install internal components.

Equipment provided with FY 1979 resources included the cooling coil, the process controls, the data acquisition and research instrumentation system and the electrical systems. The cooling coil (Figure 4), an aerodynamically shaped heat exchanger, will be installed upstream of the test section. It will serve during noncryogenic operations to remove heat generated by the fan from the flowing test medium. Also included in this work package are provisions to suitably expand the capacity of the supporting cooling tower.

Fabrication and installation of the process control system began with FY 1979 resources. This programmed, computerized system will be used to operate the tunnel in an efficient and energy conservative mode. The system will provide integrated control of fan speed, liquid nitrogen injection rates, model angle-of-attack, tunnel pressure, and the geometry of the test section.

Additionally, work was started on the fabrication and installation of the data acquisition/research instrumentation system. This system will remotely sense and record tunnel operating conditions and corresponding research data from the model under test.

Finally, FY 1979 resources were used to start fabrication and installation of electrical systems that will bring power to the facility and route it to the proper locations in the tunnel and building.

Other previously started work includes the special piping system, the drive system, and the fan components. The special piping system includes the lube oil system, the cooling water system, the high pressure compressed air system, the vacuum system, and the nitrogen admission and venting systems. The drive system includes the new synchronous 60,000 HP (44,760 KW) drive motor (Figure 7), the drive shaft, associated gear boxes, clutches, couplings and bearings, and the rewinding of an existing 4-Foot SWT motor. Fan components to be provided are the fiberglass fan blades and the attachment assemblies that connect the blades to the shaft-mounted fan disk assembly.

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FY 1980 funding will be used to complete fabrication and installation of the tunnel structure internal components and the tunnel drive system. Also to be completed with FY 1980 resources are the sitework and building. This work package includes a two-story building addition (Figure 3) to house controls, data acquisition and instrumentation systems, and the test model preparation area. Included is the vent stack (Figure 2) through which the high pressure exhaust nitrogen will flow and which will attenuate associated noise to environmentally acceptable levels.

The 1982 milestone operational date is heavily contingent on this FY 1980 element of funding. Engineering estimates at the present time indicate that the total cost of this facility will be about $85 million. This includes consideration of the results of contract solicitations to date which amount to approximately 60 percent of the total project.

Some potential design and fabrication problems still exist. Prime among the potential problem areas is completion of the fabrication and installation of the tunnel structure internal components. As can be seen in Figure 8, these components are very large, consist of many compound curved surfaces, and must be put in place as the tunnel pressure shell is being erected. Other difficult problem areas are:

- Controls optimization - math modeling of the various systems (fan speed, liquid nitrogen injection rate, tunnel pressure, etc.) to develop the most efficient controls for rapid change of the test environment.

- Seals - development of seals, to be placed between movable components, that will render repeated good performance over the expected wide range of temperature and pressure.

There is growing confidence that these problems are manageable and can be solved within the target cost, but recognition of these "unknowns" at this time is prudent.

A final environmental impact statement (EIS) for this project has been prepared and fully circulated. As indicated in the EIS, proper design, construction, and controlled operation of the completed facility will mitigate possible environmental effects, such as noise, venting of large volumes of nitrogen gas, and the possible formation of ground fog caused by venting cold nitrogen gas.

Although several studies pertaining to these areas of concern are not yet complete, findings to date indicate that acoustic treatment of the tunnel drive system and the vent stack will reduce noise to acceptable levels. Similar efforts, including pilot vent stack operation, indicate that the nitrogen can be satisfactorily vented without adverse effects. However, there may be occasions when prevailing atmospheric conditions will require the mode of tunnel operation to be somewhat modified to insure avoidance of a ground fog "problem" which might otherwise be caused by the venting of cold nitrogen gas. Work is continuing to develop the most effective combination of equipment and operational parameters to deal satisfactorily with these problems; however, it is not now felt that any of these will become impediments or offer any significant operational constraints.

PROJECT COST ESTIMATE:

The basis of this cost estimate is advanced final planning.

	Unit of Measure	Quantity	Unit Cost	Total
Land Acquisition	---	---	---	---
Construction	---	---	---	10,400,000
Sitework and building construction (Increment II)	LS	---	---	400,000
Tunnel structure components fabrication (Increment III)	LS	---	---	4,800,000
Tunnel structure components installation	LS	---	---	5,200,000
Equipment	---	---	---	1,600,000
Tunnel drive system fabrication and installation (Increment IV)	LS	---	---	1,300,000
Test section side access system fabrication and installation	LS	---	---	200,000
Model handling equipment fabrication	LS	---	---	100,000
Fallout Shelter (not feasible)	---	---	---	---
Total				12,000,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Perspective (Plan) View
Figure 3 - Second Floor Plan and Tunnel Layout
Figure 4 - Aerodynamic Lines
Figure 5 - Test Section Elevation
Figure 6 - Model Support System

Figure 7 - Fan Drive System
Figure 8 - Tunnel Structure Components
Figure 9 - Site Construction
Figure 10 - Fabricated Shell Section
Figure 11 - Funding Plan

OTHER EQUIPMENT SUMMARY:

Existing collateral equipment consisting mainly of the drive motors and a portion of the building for the 4x4-Foot Supersonic Wind Tunnel (4-Foot SWT) will be used in this facility. The estimated replacement value of this equipment is about $14 million. Although no other noncollateral equipment is required to either complete this facility or operate it for its intended purpose, it is anticipated that model calibration equipment, test support equipment, and model instrumentation technology for cryogenic testing will be required to fully exploit the capabilities of the completed facility. These non-CoF costs are programmed over several years, starting in FY 1980 and extending into the early operational years of the NTF. It is also anticipated some additional research equipment needs will be satisfied from existing inventories at LaRC.

FUTURE CoF ESTIMATED FUNDING TO COMPLETE THIS PROJECT:

At the present time, additional future CoF funding is not scheduled.

LANGLEY RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES

CONSTRUCTION OF NATIONAL TRANSONIC FACILITY
PLAN VIEW

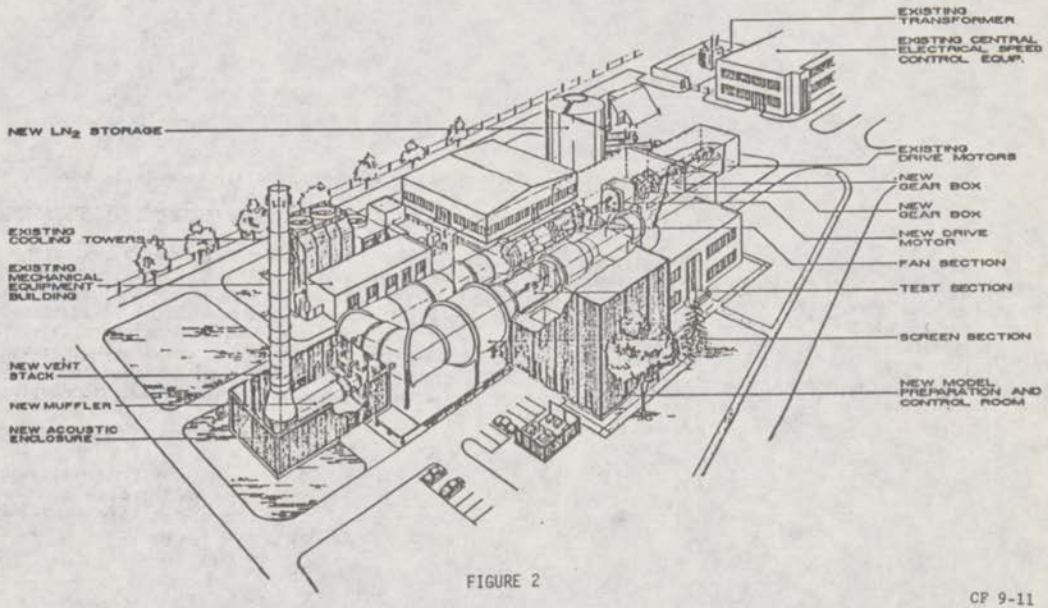


FIGURE 2

CF 9-11

LANGLEY RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES

CONSTRUCTION OF NATIONAL TRANSONIC FACILITY
SECOND FLOOR PLAN AND TUNNEL LAYOUT

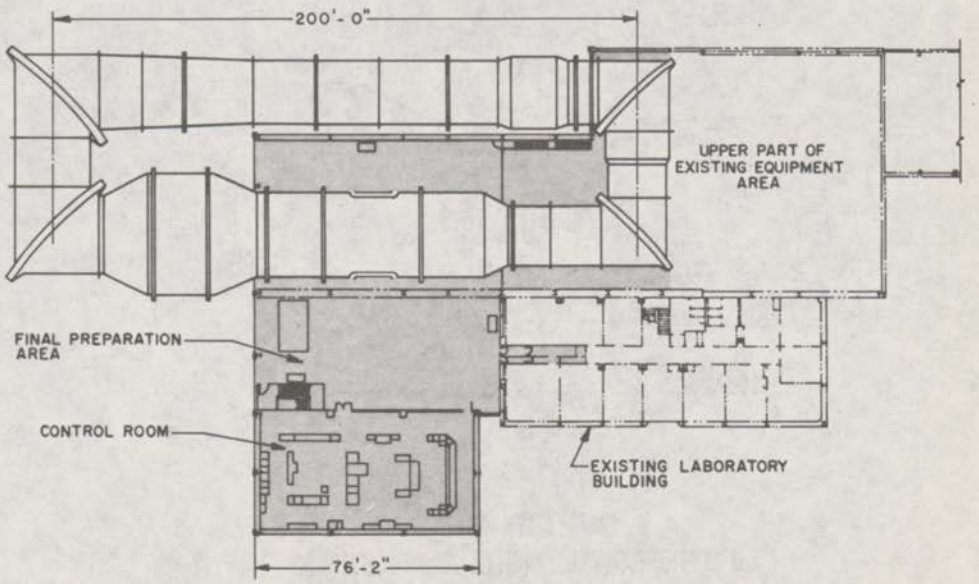


FIGURE 3

CF 9-12

LANGLEY RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES

CONSTRUCTION OF NATIONAL TRANSONIC FACILITY AERODYNAMIC LINES

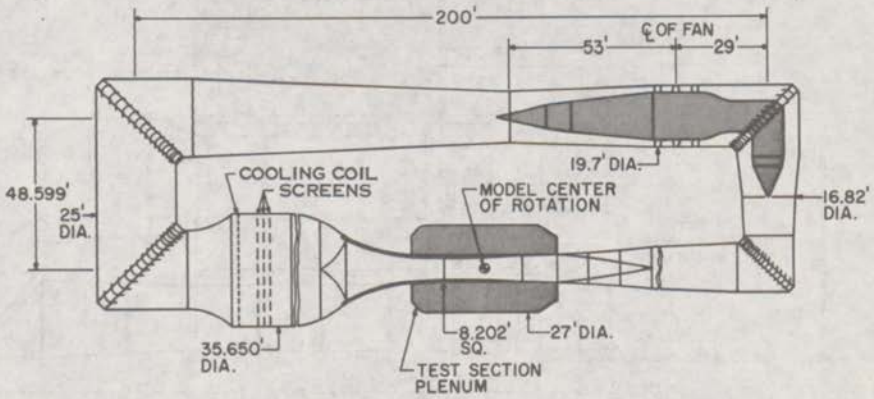


FIGURE 4

CF 9-13

LANGLEY RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES

CONSTRUCTION OF NATIONAL TRANSONIC FACILITY
TEST SECTION ELEVATION

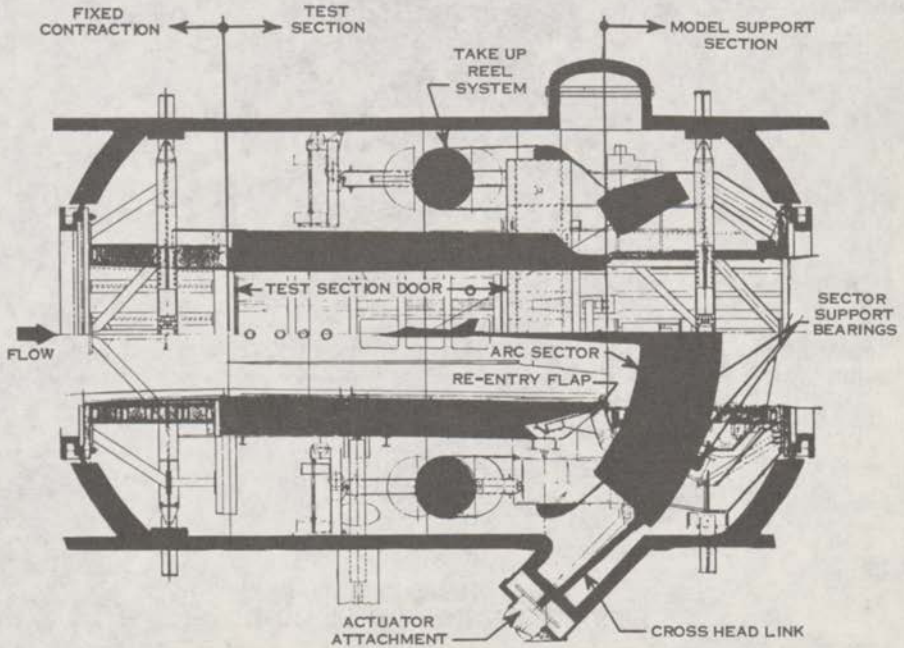


FIGURE 5

CF 9-14

LANGLEY RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES

CONSTRUCTION OF NATIONAL TRANSONIC FACILITY MODEL SUPPORT SYSTEM

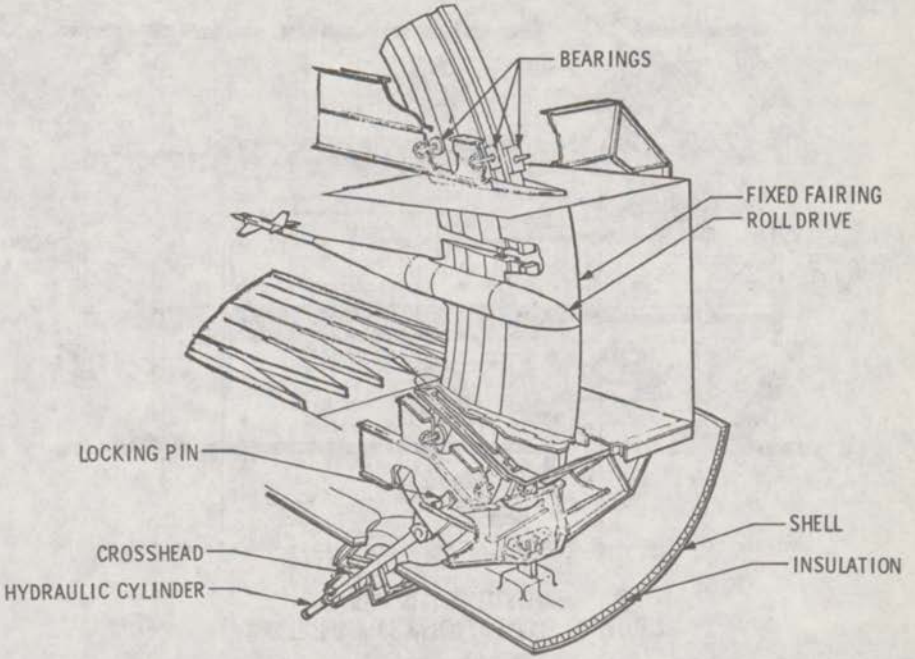


FIGURE 6

CF 9-15

LANGLEY RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES

CONSTRUCTION OF NATIONAL TRANSONIC FACILITY
FAN DRIVE SYSTEM

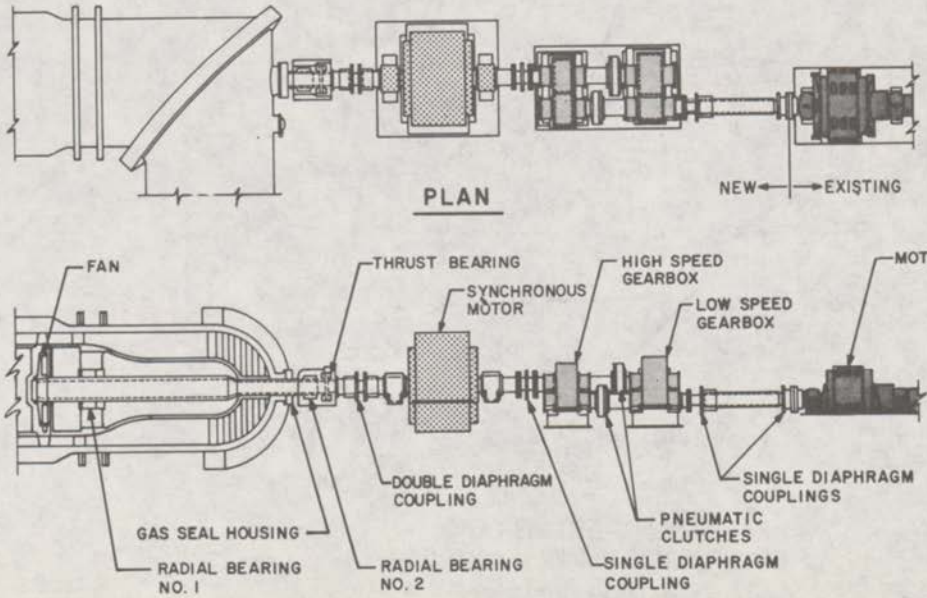


FIGURE 7

CF 9-16

LANGLEY RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES

CONSTRUCTION OF NATIONAL TRANSONIC FACILITY
TUNNEL STRUCTURE COMPONENTS

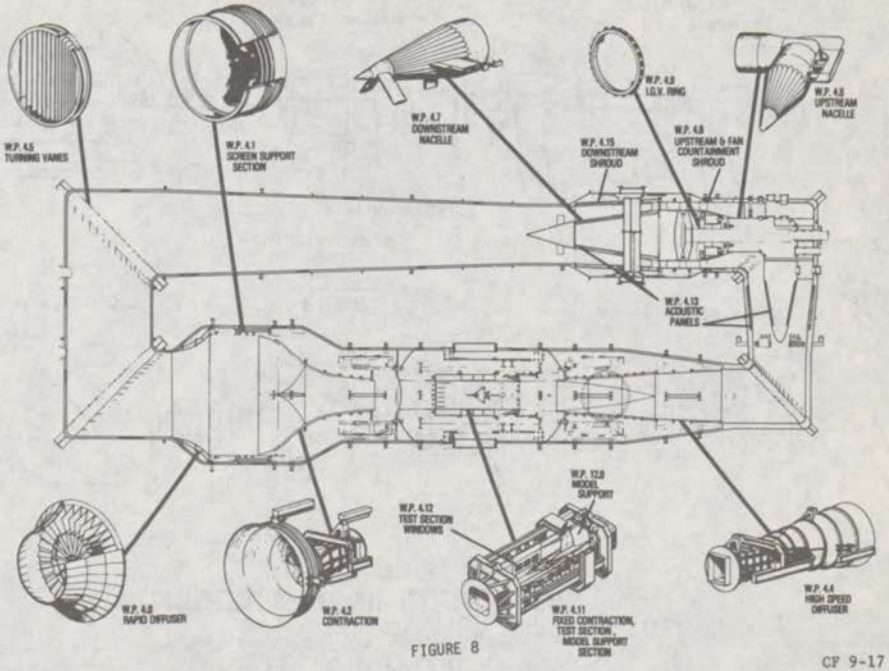


FIGURE 8

CF 9-17

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CONSTRUCTION OF NATIONAL TRANSONIC FACILITY
SITE CONSTRUCTION

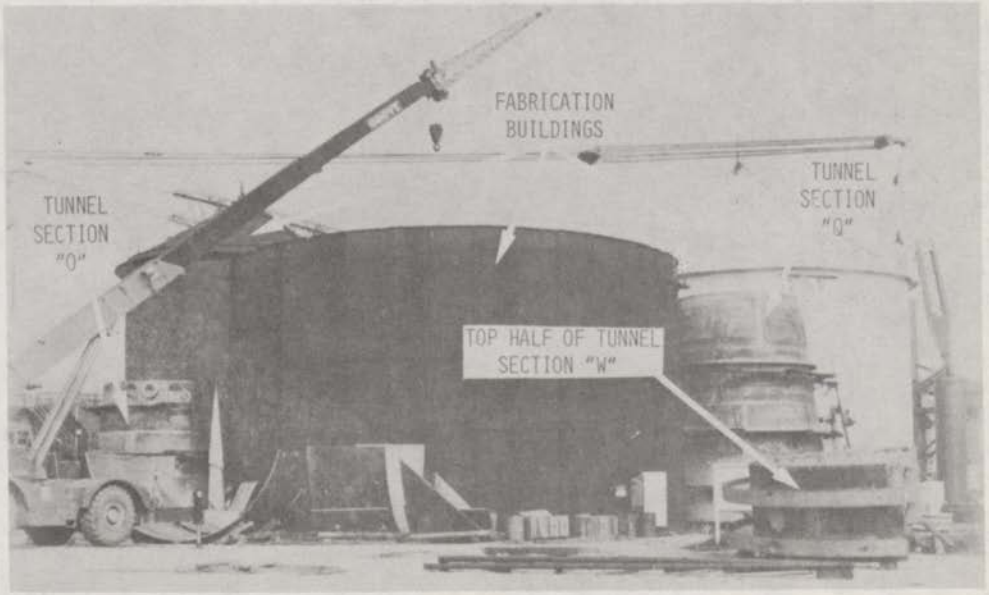


FIGURE 9

CF 9-18

LANGLEY RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES

CONSTRUCTION OF NATIONAL TRANSONIC FACILITY
TUNNEL STRUCTURE SECTION 'G'

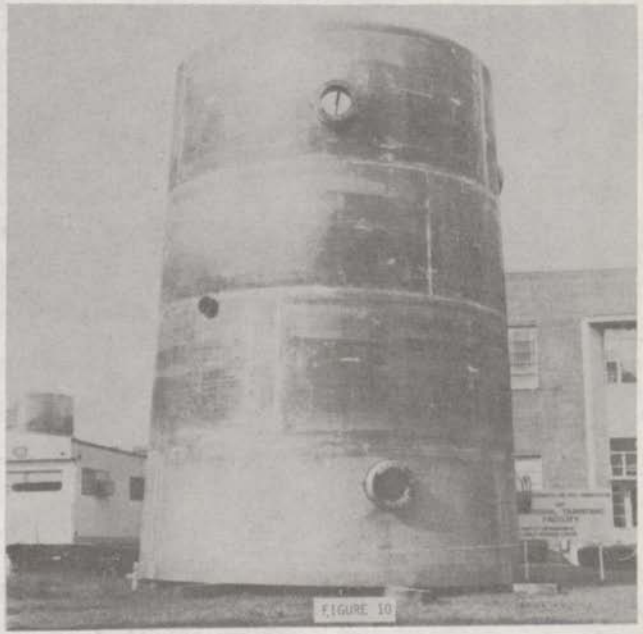


FIGURE 10

CF 9-19

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LANGLEY RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES
CONSTRUCTION OF NATIONAL TRANSONIC FACILITY
FUNDING PLAN
(Millions of Dollars)

	Fiscal Year			
	1977&1978	1979	1980	Total
Construction	37.8	9.4	10.4	57.6
Demolition, piles, and foundations	1.2	---	---	1.2
Site work and building	---	3.9	.4	4.3
Tunnel pressure shell	22.3	2.6	---	24.9
Tunnel structure components fabrication	11.4	.8	4.8	17.0
Tunnel structure components installation	---	.9	5.2	6.1
Insulation and liner	2.2	1.2	---	3.4
Nitrogen storage	.7	---	---	.7
Equipment	10.7	15.1	1.6	27.4
Special piping system	3.4	.7	---	4.1
Cooling coil	---	1.5	---	1.5
Tunnel drive system	5.2	4.4	1.3	10.9
Fan components	.6	.9	---	1.5
Model support system	1.5	---	---	1.5
Process control system	---	3.8	---	3.8
Data acquisition and research instrumentation	---	2.8	---	2.8
Test section side access system	---	---	.2	.2
Model handling equipment	---	---	.1	.1
Electrical systems	---	1.0	---	1.0
Total				
By year	48.5	24.5	12.0	85.0
Cumulative	48.5	73.0	85.0	---

FIGURE 11

CF 9-20

AMES RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

MODIFICATION OF 40-by 80-FOOT SUBSONIC WIND TUNNEL

LOCATION PLAN

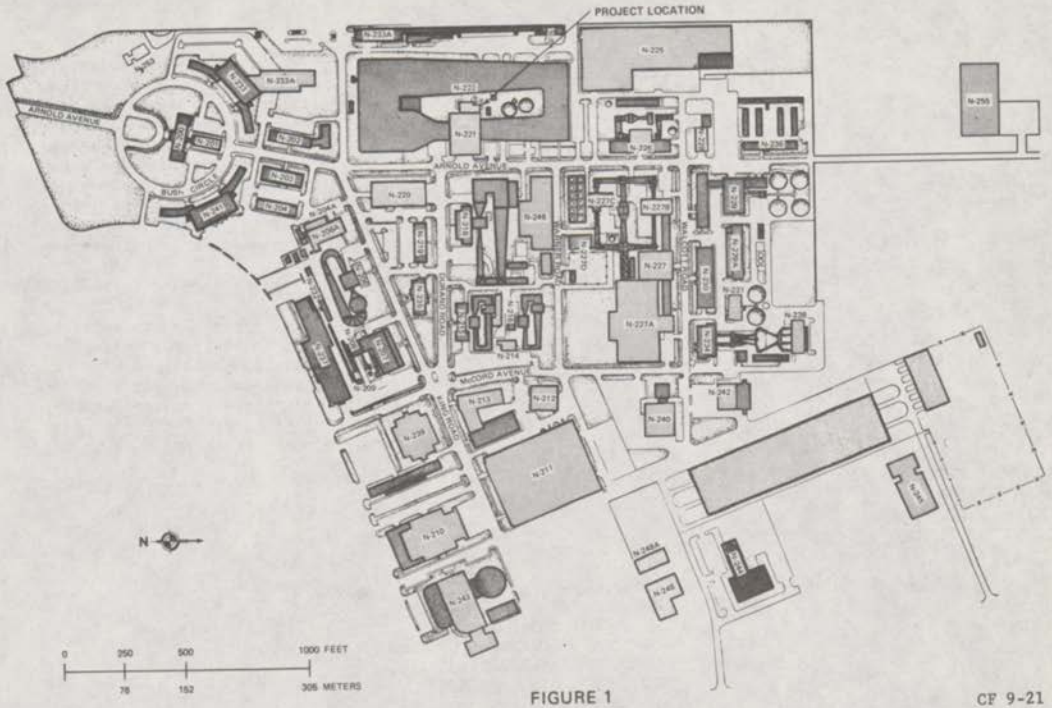


FIGURE 1

CF 9-21

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE:	Modification of 40- x 80-Foot Subsonic Wind Tunnel
INSTALLATION:	Ames Research Center
FY 1980 CoF ESTIMATE:	$33,900,000

LOCATION OF PROJECT: Moffett Field, Santa Clara County, California

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Technology

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	4,670,000	51,100,000	55,770,000
Capitalized investment	N/A	17,333,000	17,333,000
Total	4,670,000	68,433,000	73,103,000

SUMMARY PURPOSE AND SCOPE:

These resources will provide for continuing the modification of the 40- x 80-Foot (12.2 x 24.4 meters) Subsonic Wind Tunnel at Ames Research Center (ARC). The modified facility will permit the testing of rotorcraft at speeds up to 300 knots (154 meters per second). Additionally, a new 80- x 120-Foot (24.4 x 36.6 meters) test section, which is part of this total modification project, will allow for the testing of full-scale vertical and short takeoff and landing (V/STOL) aircraft including large rotorcraft in the speed range of 5 to 100 knots (2.6 to 51 meters per second). The location of the 40- x 80-Foot Subsonic Wind Tunnel is shown in Figure 1. The major items of work involved in this total project are shown in Figure 2. This project is

being implemented with multiyear resources of which the FY 1980 estimate is the fourth funding element. Additional funding is not presently planned for the attainment of an initial operational capability under this project as now defined, since the present cost estimate is $85 million.

PROJECT JUSTIFICATION:

Modifications to the 40- x 80-Foot Subsonic Wind Tunnel will provide a National facility with a capability for research as well as development tests of full-scale rotorcraft and other V/STOL aircraft. Both civil and military rotorcraft have advanced significantly in speed capability over the last decade and can no longer be adequately evaluated in any existing test facility. Furthermore, V/STOL technology exemplified by the Advanced Harrier AV-8B has advanced to the extent that full-scale testing of flight configurations is now required. This manner of testing is essential to optimal solution of the complex problems of propulsion system/airframe structure/control interactions.

The usefulness of wind tunnel testing prior to flight testing has been demonstrated in a wide variety of test programs conducted in this facility in the past three to five years. These include V/STOL aircraft such as the OV-10A, XV-5, H-126, and AV-8B; STOL aircraft such as the F-14, F-15, F-111B, and A-37; rotorcraft such as the XV-15, AH-56A, and ABC flight rotor; propulsion systems such as the Q-Fan and J-79; recovery devices such as the B-77 drogue chute and full-scale parawings; and the space shuttle orbiter. In spite of these successful testing programs, the growing limitations of current test facilities were recognized as early as 1967 by the Aeronautics and Astronautics Coordinating Board (AACB). It was AACB-initiated studies that ultimately suggested a modification to the 40- x 80-Foot Subsonic Wind Tunnel.

Initial studies addressed the feasibility of constructing a new full-scale wind tunnel which would accomplish defined testing requirements. The projected cost of $300 million (1973 dollars) was considered excessive and alternative solutions were then pursued. Subsequent studies showed that essentially the same capability could be achieved by retrofitting the 40- x 80 drive support structure with a new generation drive system and by the addition of a new test leg. Since this modified tunnel would satisfy most testing needs at considerable monetary savings, it was presented to and subsequently approved by the AACB in 1973.

The higher wind speed provided by the modified 40- x 80-foot test section is necessary to properly evaluate high-speed rotor systems presently under development for both civil and military mission roles. Aerodynamic response of rotorcraft systems, for instance, can be best understood by wind tunnel studies. These studies lead to economical and structurally acceptable designs while reducing noise levels and improving flight performance. The Advancing Blade Concept (ABC) helicopter and the XV-15 typify the kinds of advanced rotorcraft which require the increased speed capability of the modified tunnel.

The large 80- x 120-foot subsonic test section is needed to eliminate the tunnel wall interference problems and the large wake "downwash angles" which are Reynolds number sensitive and difficult to reproduce accurately at less than full-scale. Certain mechanical and structural aspects of high lift systems, such as air leaks and deflection under load, can significantly affect test results of aerodynamic performance. The main problem for V/STOL aircraft is usually the propulsion system and its interface with the aircraft. Certain components of the propulsion system (rotor or fan blades, inlets, vectoring devices, etc.) operate in the range of Reynolds numbers where significant variations in aerodynamics occur. Additionally, there are important aeroelastic, mechanical, and structural aspects of these propulsion systems that require extensive experimental studies using full-scale or flight hardware. The major technical risks of V/STOL aircraft employing low disk-loading rotor systems are associated with dynamic loads, dynamic stability, and control of the rotor system. These characteristics are highly dependent on the unsteady aerodynamic force inputs to the rotor and on the dynamic characteristics of the rotor and its control system, including backlash, breakout forces, and nonlinear effects. Again, the Tilt Rotor Research Aircraft (XV-15) now being developed is typical of a low disk-loading V/STOL aircraft which requires full-scale wind tunnel testing. V/STOL aircraft which employ high disk-loading, direct-lift propulsion systems develop problems in hovering and in the transition to wing-supported flight. The lift propulsion system in the transition flight regime is generally required to operate in a highly distorted, unsteady and turbulent flow field. Resulting high vibratory loads on fan blades may produce catastrophic failures in flight due to fan or engine stalling. It is therefore essential that the characteristics of the propulsion system, as installed in the aircraft, be determined in ground-based facilities prior to committing the hardware to flight. This is particularly true for high powered V/STOL aircraft and is also relevant for high-performance CTOL fighter-attack aircraft.

It is anticipated that approximately 70 percent of the available wind tunnel time will be devoted to such research work as rotor aerodynamic/dynamic interactions, aircraft aerodynamic/propulsion interactions, engine/airframe integration, V/STOL propulsion control system, and noise/gust alleviation. Developmental problems of rotorcraft and other V/STOL aircraft, as well as CTOL fighter-attack aircraft, will consume the remaining wind tunnel time. These developmental problems include configuration definition, system integration and evaluation, and performance improvement. NASA, in general, will sponsor the research activities, and DOD and industry will be the prime developmental testing users.

Additional program responsibilities recently assigned to Ames Research Center have altered the schedule requirements for the modified 40- x 80-Foot Subsonic Wind Tunnel. A minimum of two shifts per day and a 5-day week is now projected to meet these programmatic demands in 1982, recognizing that some testing backlog may develop. The available test time projected for this facility will be shared by NASA (70 percent), DOD (25 percent), and industry working on DOD programs (5 percent).

In summary, successful research and developmental testing of civil and military advanced rotorcraft and other V/STOL aircraft now being scheduled require that the 40- x 80-Foot Subsonic Wind Tunnel be repowered to increase the maximum wind speed and be modified to incorporate the new test leg by early 1982. Funding must therefore be continued for those contracts whose procurement was initiated with prior year resources and for completing the new leg construction to be initiated with FY 1979 resources. The tunnel will not be available for research for a period of 10 to 12 months starting in early to mid-1980, when construction and calibration activities will be accomplished. The primary impact of this downtime will be on NASA's long-range test programs, which may be delayed with minimum program disruption. There are no known programs from other agencies which must be accomplished during this period.

IMPACT OF DELAY:

Examination of the factors affecting both the military and the civil requirements indicates that there will be an urgent need for advanced rotorcraft and other V/STOL aircraft in the 1985 to 1990 time period. In order to provide the critical technology for these aircraft, the expanded test capability provided by this modified facility must be available well before this time frame. The current construction schedule calls for facility completion in 1982 which is the latest date acceptable if an adequate technology base is to be available by 1990. Delays in providing added funds to previously awarded multiyear funded contracts could well also result in contractor claims for termination costs or schedule extensions. Those contracts not yet awarded can also be expected to rise in cost if delayed because of the high escalation rates currently being experienced.

PROJECT DESCRIPTION:

Repowering will increase the maximum test speed of the 40- x 80-foot test section from 200 to 300 knots. This increased capability will be achieved through an increase in drive system power. The six existing 6,000 HP (4,500 KW) induction motors will be replaced with six new 22,500 HP (16,800 KW) synchronous motors (Figure 4), and the existing 6-bladed, fixed-pitch fans will be removed and new 15-blade, variable-pitch fans (Figures 3 and 5) will be installed. The total drive system will be increased to 135,000 HP (101,000 KW) from 36,000 HP (27,000 KW). The wind tunnel will be repowered within the present drive-section structure. Frequency control for varying fan rotational speed will be provided by the existing motor generator set which requires some modification. This combination of variable-pitch fans and frequency control will provide a precisely controlled speed range of 5 to 300 knots (2.6 to 154 meters per second) within the 40- x 80-foot test section.

Figure 2 shows the 80- x 120-foot test leg which will be added just upstream of the drive motor section. This new leg will include the new test section transition and flow-directing equipment, the entrance cone, and sound muffling treatment. Air will be inducted at the entrance cone; flow through the 80- x 120-foot section, the drive motor section, and portions of the existing wind tunnel circuit; and finally exhaust to the atmosphere

through the new air exit louvers. As shown in Figure 3, air flow diversion vanes and louvers, together with adjustable turning vanes, will be installed to permit operation in either the 40- x 80- or in the 80- x 120-foot mode.

The entire project is being funded over a period of several fiscal years. Funds in the amount of $51.1 million have been provided in prior year appropriations for the facility modification. The program plan for FY 1977 through 1980 funds is summarized in Figure 5. The FY 1977 increment provided for the initiation of procurement for the main drive motors and controls, the fan and stator blades, the fan hub and variable pitch mechanism, and the relocation of the Ames' electrical power substation. The second increment of funding for the long-lead items was included in the FY 1978 estimates. FY 1978 resources also provided for the initial sitework, structural modifications, and the new balance and model support system for the 80- x 120-foot test section. Both the FY 1978 and FY 1979 budget requests included funds for continuing the funding of contracts awarded with prior year resources. The FY 1979 request also included funds required to initiate the construction of the "new leg." Funds have been included in the FY 1980 budget request to complete the "new leg" construction to include painting and finishing, and fabrication and installation of the fire protection system, the model handling system, the test section doors, and the floor panels.

Several significant risks remain which may impact the final configuration of the modified facility. The present wind tunnel requires some structural modifications to support increased air loads; to allow for operation of the new leg circuit; and to support the new larger drive system. Recent bids received on the associated structural steel modification contracts have exceeded the government estimate. After evaluating these bids, it was determined that a redesign effort to reduce costs was necessary. This redesign has caused a slip to early 1982 in the estimated operational dates for the modified facility. Additional risks associated with installation of the drive system and fabrication of the flow straighteners clearly show that this project faces major technical and managerial challenges. Increased staffing together with intensive scheduling and cost control techniques will continue to assist in isolating and resolving these critical "problems." On-going efforts to identify and eliminate work elements not essential to the Initial Operating Capability (IOC) will also assist in controlling project costs.

The Ames Research Center's Environmental Impact Statement has been amended to cover the Modification of the 40- x 80-Foot Subsonic Wind Tunnel. The final statement was submitted to the Council on Environmental Quality (CEQ) and made available to the public on July 5, 1977. Comments received subsequent to publication revealed noise to be the only item of significance. Experimental tests have been performed which demonstrate that the noise generated by the modified facility will be less than of the current configuration. It is probable that noise levels presently predicted are conservative and that the actual levels will be even lower than now estimated. Consequently, this earlier concern should not constitute a problem.

PROJECT COST ESTIMATE:

This cost estimate is based on varying degrees of final planning, design and contract awards.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	23,100,000
Site work and utilities (Increment IV)	LS	---	---	400,000
Structural modifications (Increment III)	LS	---	---	13,100,000
Structural erection (Increment IV)	LS	---	---	3,000,000
Acoustical treatment (Increment III)	LS	---	---	5,000,000
Painting and finishing	LS	---	---	900,000
Fire protection	LS	---	---	300,000
Miscellaneous mechanical	LS	---	---	400,000
Equipment	---	---	---	10,800,000
Main drive assembly and installation (Increment III)	LS	---	---	3,200,000
Main drive system fabrication (Increment IV)	LS	---	---	1,500,000
Fan and stator blades fabrication (Increment IV)	LS	---	---	500,000
Electric installation (Increment II)	LS	---	---	2,500,000
Model auxiliary systems	LS	---	---	400,000
Test section doors and floor panel fabrication	LS	---	---	1,100,000
Model support and turntable fabrication (Increment II)	LS	---	---	1,100,000
Data acquisition & operation control system fabrication (Increment III)	LS	---	---	500,000
Fallout Shelter (not feasible)	---	---	---	---
Total				33,900,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Site Plan
Figure 3 - Vanes, Louvers, and Fan Drive System
Figure 4 - New Fan Drive Unit
Figure 5 - Program Plan

OTHER EQUIPMENT SUMMARY:

Existing collateral equipment consisting mainly of the model support system, the balance, the motor generator sets, the rheostat, and other equipment of the present 40- x 80-Foot Subsonic Wind Tunnel will be used with this modification project. The total replacement value of the present 40- x 80-Foot Subsonic Wind Tunnel is approximately $70 million. Existing noncollateral equipment valued at about $1.5 million, which consists primarily of computers, will also be used in the new facility. No major additional noncollateral equipment is involved.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

Current cost reviews for this facility modification work, with capabilities as currently configured, support an $85 million estimate. Thus, additional future CoF funding is not scheduled.

AMES RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

MODIFICATION OF 40-by 80-FOOT SUBSONIC WIND TUNNEL

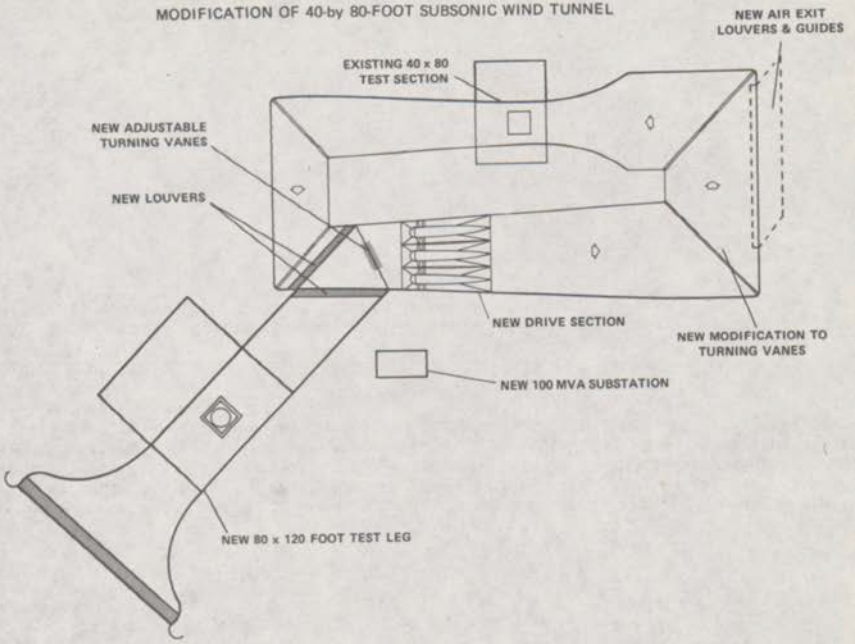


FIGURE 2

CF 9-29

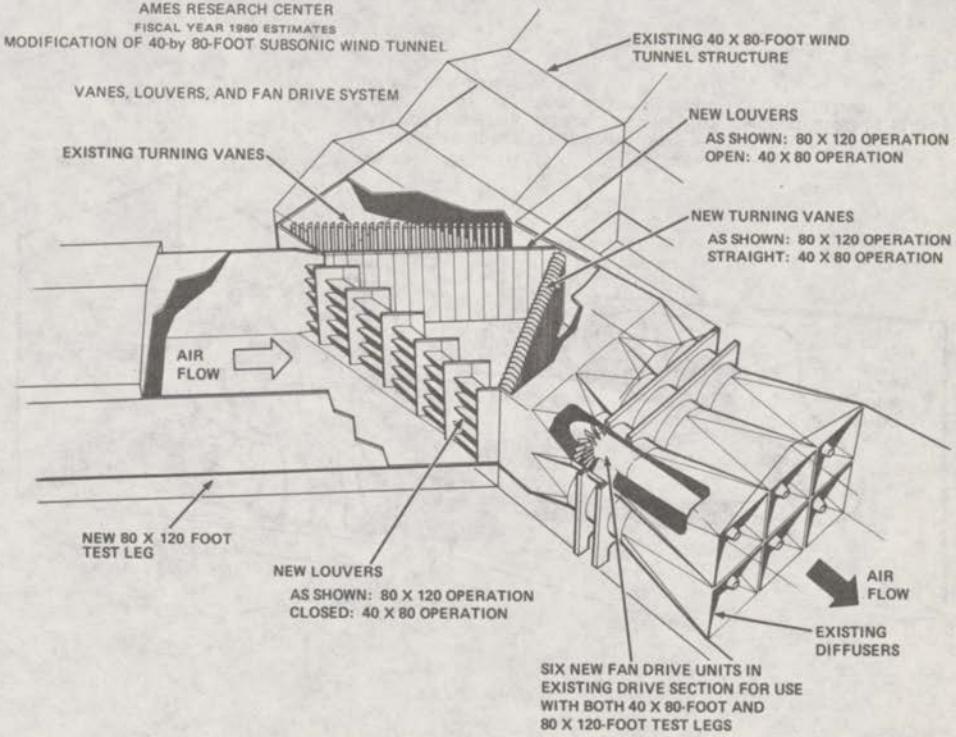


FIGURE 3

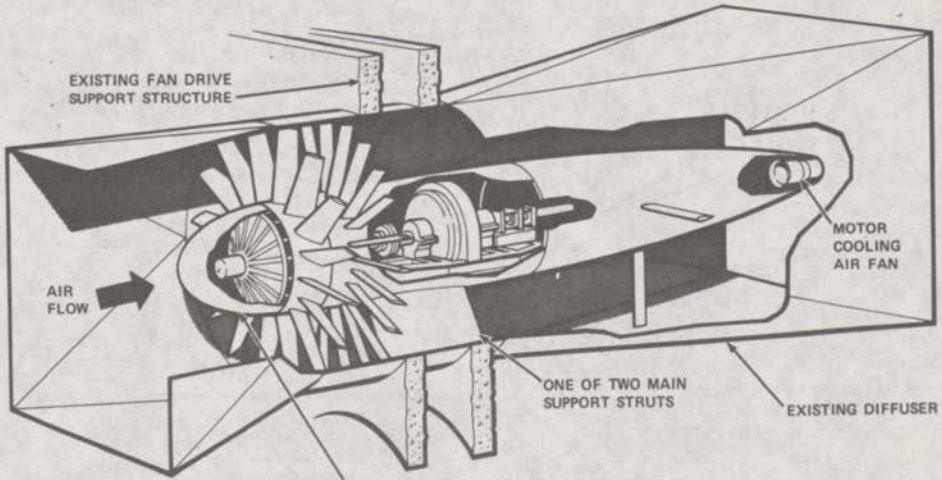
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AMES RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

MODIFICATION OF 40-by 80-FOOT SUBSONIC WIND TUNNEL

NEW FAN DRIVE UNIT



22,500 HORSEPOWER ELECTRIC MOTOR
40-FOOT DIAMETER 15-BLADE VARIABLE-PITCH FAN, AND 23-BLADE STATOR
CENTER BODY – 17.5-FOOT MAX DIAMETER BY 138.5 FEET LONG
DRIVE UNIT WEIGHT: 400,000 LBS.

FIGURE 4

CF 9-31

AMES RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES
MODIFICATION OF 40- BY 80-FOOT SUBSONIC WIND TUNNEL
FUNDING PLAN
(Millions of Dollars)

	Fiscal Year				
	1977	1978	1979	1980	Total
Construction	.1	4.2	13.6	23.1	41.0
Site work and utilities	---	.2	.1	.4	.7
Piles and concrete	---	.3	1.6	---	1.9
Structural modifications	---	1.5	3.4	13.1	18.0
Structural erection	.1	1.2	6.6	3.0	10.9
Painting and finishing	---	---	.1	.9	1.0
Fire protection	---	---	---	.3	.3
Acoustic treatment	---	1.0	1.8	5.0	7.8
Miscellaneous mechanical	---	---	---	.4	.4
Equipment	5.9	9.3	18.0	10.8	44.0
Main drive assembly and installation	---	---	1.5	3.2	4.7
Main drive system	1.6	1.3	3.3	1.5	7.7
Main drive power supply	.8	.5	1.1	---	2.4
Fan and stator blades	1.2	1.6	2.3	.5	5.6
Fan hub and variable pitch mechanism	1.7	.4	1.2	---	3.3
Nacelle, fairings, and spinner	---	1.7	2.5	---	4.2
Electric installation	---	---	1.4	2.5	3.9
Substation relocation	.6	.8	2.1	---	3.5
Model handling system	---	---	1.4	---	1.4
Model auxiliary systems	---	---	.1	.4	.5
Test section doors and floor panels	---	---	---	1.1	1.1
Model support and turntable	---	1.8	---	1.1	2.9
Model balance system	---	1.2	1.1	---	2.3
Data acquisition and operation control systems	---	---	---	.5	.5
Total	6.0	13.5	31.6	33.9	85.0

FIGURE 5

CF 9-32

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

SUMMARY

SPACE SHUTTLE FACILITIES

	Amount	Page No.
Office of Space Transportation Systems:		
Summary		CF 10-1
Launch and Landing Facilities:	18,950,000	
Modifications to launch complex 39 (KSC)	17,700,000	CF 10-4
Modifications to crawler transporter maintenance facility (KSC)	1,250,000	CF 10-16
Manufacturing and Final Assembly Facilities:	10,000,000	
Modification of manufacturing and final assembly facilities for external tanks (MAF)	10,000,000	CF 10-24
Minor Facilities:	2,500,000	
Minor shuttle-unique projects, at various locations	2,500,000	CF 10-40
Total	31,450,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE: Space Shuttle Facilities

INSTALLATION: Various Locations

FY 1980 CoF ESTIMATE: $31,450,000

LOCATION OF PROJECT: Locations are identified in the following documentation.

COGNIZANT HEADQUARTERS OFFICE: Office of Space Transportation Systems

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	14,934,500	178,781,500	193,716,000
Capitalized investment	N/A	635,865,220	635,865,220
Total	14,934,500	814,646,720	829,581,220

The above data summarizes only the projects included in this submittal. Before FY 1980, $31.3 million was made available for Shuttle planning and design in addition to $343.7 million for Shuttle facilities construction.

SUMMARY PURPOSE AND SCOPE:

The purpose of this project is to rehabilitate, modify, and add to existing Government-owned facilities, and to construct those limited new facilities to meet unique requirements of the Space Shuttle Program. As in prior years, this Shuttle facility package includes all major facility requirements unique to the Space Shuttle Program. In FY 1980, the proposed Shuttle facilities are related to the launch and landing requirements at

John F. Kennedy Space Center (KSC) and the external tank manufacturing and final assembly at Michoud Assembly Facility (MAF). The projects included in this request are as envisioned at the time of the FY 1979 budget with minor adjustments in scope necessary to accommodate program developments. Also included are minor rehabilitation and modification projects which are required to support the Space Shuttle and are therefore considered unique Space Shuttle projects.

PROJECT JUSTIFICATION:

Prior years CoF projects for the Space Shuttle Program authorized modification and construction of facilities for technical development, Space Shuttle main engine tests, ground tests, manufacturing, and launch and landing. All of the facilities to support the first Manned Orbital Flight and the Development, Design, Test and Evaluation portion of the program will be completed in 1978 with activation intensifying on the launch facilities at KSC. The FY 1980 request is intended to continue to provide launch capability for the Space Shuttle vehicle at KSC. The primary element in this request is a continuation of Pad "B" modifications. Pad "B" is planned to be operational by late 1983 at which time it will be needed to support the planned launch rate as well as provide needed operational reliability and flexibility. Also at KSC is a project for Modifications to the Crawler Transporter Maintenance Facility. The major discrete project at MAF provides for the continuation of manufacturing and final assembly of the external tank.

The facilities included in this request have been carefully reviewed to insure they are not brought into the program prematurely but as required to support planned operational capabilities.

43-643 O - 79 - 43

PROJECT COST ESTIMATE:

Launch and Landing Facilities	18,950,000
Modifications to Launch Complex 39, Kennedy Space Center	17,700,000
Modifications to Crawler Transporter Maintenance Facility, Kennedy Space Center	1,250,000
Manufacturing and Final Assembly Facilities	10,000,000
Modification of Manufacturing and Final Assembly Facilities for External Tanks, Michoud Assembly Facility	10,000,000
Minor Facilities	2,500,000
Minor Shuttle - Unique Projects, Various Locations	2,500,000
Total	31,450,000

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1980 ESTIMATES

MODIFICATIONS TO LAUNCH COMPLEX 39

CP 10-4

LOCATION PLAN

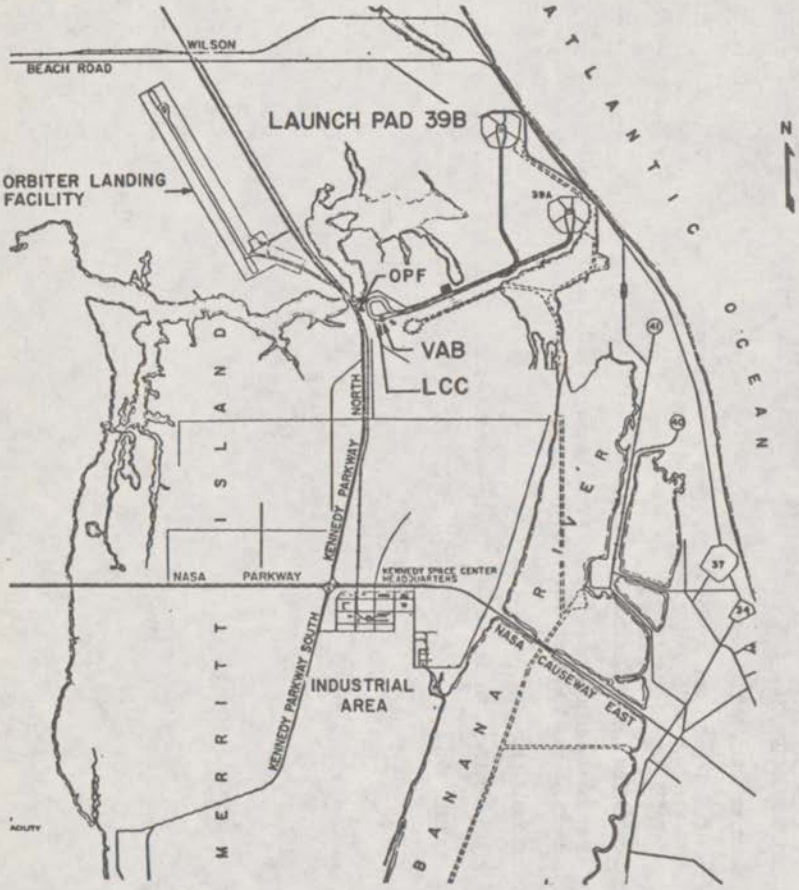


FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE:	Modifications to Launch Complex 39
INSTALLATION:	John F. Kennedy Space Center
FY 1980 CoF ESTIMATE:	$17,700,000

LOCATION OF PROJECT: Merritt Island, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Transportation Systems

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	9,810,000	123,530,000	133,340,000
Capitalized investment	N/A	501,538,000	501,538,000
Total	9,810,000	625,068,000	634,878,000

SUMMARY PURPOSE AND SCOPE:

This project continues modifications to Launch Complex 39 (LC-39), begun with FY 1975 resources and continued with FY 1976, FY 1977, FY 1978, and FY 1979 resources to support Space Shuttle operations. The FY 1975, FY 1976, and a portion of the FY 1977 resources provided for modifying two high bays in the Vehicle Assembly Building (VAB), the Launch Control Center, one mobile launch platform, and Launch Pad "A." These initial LC-39 facilities were those essential for the launch of the First Manned Orbital Flight. The balance of the 1977 project coupled with 1978 resources provided for modifying the second mobile launch platform, the two remaining high bays in the VAB, and initial modifications to Launch Pad "B." The FY 1979 project continued modifications

to Launch Pad "B", and provided freon recovery and hypergol support facilities and rehabilitation of roads in the LC-39 area. This year's work provides for completing modifications to Launch Pad "B," specifically for the construction of the Rotating Service Structure and launch systems and other construction, modification and rehabilitation work in the LC-39 area.

PROJECT JUSTIFICATION:

The Space Transportation System (STS) operational phase will begin after the first six Space Shuttle development flights in CY 1979 and CY 1980. Launch rates will increase gradually to a maximum of 40 flights per year in the mid-1980's. During this operational phase, the risk of having only one launch pad in the early years is conditionally acceptable. By late 1983, launch rates and the attendant risks associated with a single launch pad make a second launch pad essential. Prior year resources provided for the beginning of modifications to Launch Pad "B." This year's project will complete the work on Pad "B" to allow it to be operational by late 1983.

Vital operations on the launch pad must take place before final countdown and launch of the Space Shuttle. These activities include performing final checkout of vehicle systems, loading propellants in the external tank, and loading hypergolic propellants in the auxiliary propulsion system pods and the reaction control system. Power reactants and cooling and life support fluids must also be loaded; payloads may be inserted, prepared, or changed; and the crew must be boarded. During the early years of the Space Transportation System operational phase, the functions described above will be performed on a single launch pad (Pad "A"). Should there be any large variations in on-pad operations due to checkout problems, adverse weather, or the unknowns associated with Department of Defense payloads or planetary missions, schedules could be drastically affected. Such delays are conditionally acceptable in the early years of the STS operational phase. As the launch rate increases however, these delays become less and less acceptable as they adversely impact schedules. In addition, should any damage to the launch pad occur during launch, subsequent launches will have to be delayed while repairs are being made. By early 1983 when flight rates are expected to increase considerably, a significant operational risk develops until Pad "B" is completed. As a consequence, it is felt that Pad "B" must be operational by late 1983 so that the Space Transportation System is not adversely affected. December 1983 is thus the latest acceptable operational ready date for Launch Pad "B" and is a critical milestone.

Recent predictions of the solid rocket motor exhaust gas pressures on the blast deck of the Mobile Launch Platform (MLP) indicate that in some cases the load will be greater than that for which the deck is currently configured. This necessitates a strengthening of structural members, and a stiffening of the blast deck. MLP-1 will be modified for this purpose with prior year resources while MLP-2 will be modified with this FY 1980.

project. Other facilities generally associated with the total LC-39 complex must also be provided or further modified with FY 1980 resources. These include construction of work support and staging facilities, Pad "B" support area, modifications to the Propellant Laboratory and Mobile Equipment Maintenance Shop and rehabilitation of the Vendor Tanker Staging Area.

The Launch Control Center (LCC) roof is in poor condition and in need of repair. Its top surface is blistered, and water collects due to inadequate slope and insufficient drainage. The vapor barrier has been ruptured in several locations, causing leaking. Normal repair efforts have not been successful in halting the degeneration of this roof. Important Shuttle launch control operations are conducted in this building. As this roof continues to leak in spite of repair efforts, the risk of damage to expensive equipment and interference with critical operations grows. It is essential to rehabilitate this roof as planned so as not to interfere with later critical Shuttle operations.

Integrated resource requirements for all of Launch Complex 39 are shown in Figure 5. While it was originally planned that the $27.1 million of the FY 1978 resources provided would be available for application to the Rotating Service Structure, later needs associated with both Mobile Launch Platforms, the Vehicle Assembly Building, and Launch Pad "A" have required the allocation of these resources to those facilities. It is now estimated that $21.4 million of FY 1978 and $12.8 million of FY 1979 resources will be available for Pad "B" work. As a consequence, $8.0 million will be required in FY 1980 for the Rotating Service Structure and $7.1 million will be required for the launch systems. In addition, $2.6 million will be required for the other work in the LC-39 area, as outlined above, and the deck "beef-up" of MLP-2.

IMPACT OF DELAY:

If this project is not funded in FY 1980, it will be impossible to complete Launch Pad "B" by its need date of December 1983. In light of launch rates projected for that period and the fact that two orbiters could be tied up if the single launch pad were damaged, this is not a prudent risk. Similarly, it is felt that the other work in the LC-39 area, if deferred, could drastically impact Shuttle operations and this is not an acceptable risk.

PROJECT DESCRIPTION:

This project provides for continuing modifications to Launch Pad "B" begun with FY 1978 resources. Prior year resources provided for site work, piling and foundations, construction of a fixed service tower, a flame deflector, and an acoustic reduction system. Existing structural, mechanical, and electrical systems were also modified. The FY 1979 project, coupled with this FY 1980 project, provides a Rotating Service Structure (RSS) mounted on rails on the surface of the launch pad which is attached to the Fixed Service Structure (FSS)

(Figure 2). The Rotating Service Structure (Figure 3) consists primarily of a rotating bridge, the Payload Changeout Room (PCR), a system of external and internal access platforms, and a powerful drive system for moving the RSS away from the orbiter when it is ready for launch. The rotating bridge is constructed of large tubular steel members welded into the configuration shown in Figure 3. On top of the rotating bridge and attached to it is the Payload Changeout Room, approximately 52 feet wide by 50 feet deep by 76 feet high (15.8 meters by 15.2 meters by 23.3 meters). The PCR provides a clean environment where payloads can be removed or inserted into the orbiter's payload bay; thus, an extensive environmental control system is an essential part of the PCR. Within the PCR, an elaborate system of fixed platforms capable of extending and retracting is provided for checkout and servicing of payloads. A service elevator connects the platforms so that various pieces of support equipment can be moved between the levels of the PCR. Additionally, hoisting systems are provided for handling payloads within the PCR and for their transfer into the orbiter payload bay.

Another room, approximately 32 feet wide by 27 feet deep by 30 feet high (9.8 meters by 8.2 meters by 9.1 meters), located above the PCR, will provide access to the Shuttle forward reaction control system, while platforms beneath the PCR will provide access to the Shuttle aft propulsion system. Additional access to the orbiter, solid rocket boosters, and the external tank for last minute inspection and possible repairs is provided by platforms, swinging arms, and other devices. The entire Rotating Service Structure moves by its own power from the position where it is mated with the orbiter (Figure 2) to its retracted position (Figure 3). This movement is accomplished by means of large traction motor drive systems attached to the legs of the Rotating Service Structure and moving on a fixed rail system. Operations on payloads or the build-up of payloads will normally take place while the RSS is moved away from the flight vehicle, whereas final insertion of the payload into the orbiter and fueling of the flight vehicle will occur while the RSS is in its forward position mated to the Shuttle vehicle.

This work also provides for extensive modifications of the launch systems, including the environmental control, pneumatic, fuel, and high-pressure gas systems on Pad "B". In addition, MLP-2 will be modified by structurally beefing up main members and the blast deck to withstand the increased predicted blast pressures.

The existing flat roof of the LCC, which is badly blistered and leaking, will be stripped down to the vapor barrier, new roof drains will be installed, expansion joints will be provided, and all roof penetrations will be reflashed. A new layered roof of asphaltic felt covered with lightweight concrete will then be installed. This process, although more expensive than usual, is essential if the roof is to be adequately sloped to solve the existing drainage problem. A top covering of fiberglass felts with roof vents and a final seal coat will be applied. The general layout of the LCC roof can be seen in Figure 4. Work support and staging facilities for the overall LC-39 area and a Pad "B" support facility will be constructed using pre-engineered metal

buildings. The existing Propellant Laboratory and Mobile Equipment Maintenance Shop will be expanded by adding a 900 square foot (83.7 square meters) storage area. An additional maintenance bay will also be constructed inside the Mobile Equipment Maintenance Shop.

PROJECT COST ESTIMATE:

The bases of this cost estimate are the final design for the Pad "B" portion and Preliminary Engineering Reports for other LC-39 work.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	17,700,000
Construct rotating service structure	LS	---	---	8,000,000
Modify launch systems	LS	---	---	7,100,000
Environment control system	LS	---	---	(1,270,000)
Pneumatic systems	LS	---	---	(1,040,000)
Propellent and high pressure gas systems	LS	---	---	(950,000)
Fuel systems	LS	---	---	(2,220,000)
Electrical/communication systems	LS	---	---	(1,620,000)
Modify Mobile Launch Platform-2	LS	---	---	1,100,000
Construct work support and staging facilities	LS	---	---	900,000
Roof rehabilitation - LCC	LS	---	---	600,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				17,700,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Perspective - Launch Pad "B"
Figure 3 - Rotating Service Structure
Figure 4 - Roof Layout - LCC
Figure 5 - Resource Requirements, LC-39

OTHER EQUIPMENT SUMMARY:

It is anticipated that approximately $30 million of R&D resources will be required to provide noncollateral equipment for initial operation of facilities included in the project.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

At the present time, no major future requirements for LC-39 have been firmly identified. However, should Mobile Launch Platform #3 be later validated, its cost would be added at approximately $18 million. In the same manner, if further major programmatic modifications to LC-39 facilities are so required, their cost of execution must also be additive.

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1980 ESTIMATES
MODIFICATIONS TO LAUNCH COMPLEX 39

PERSPECTIVE
LAUNCH PAD "B"

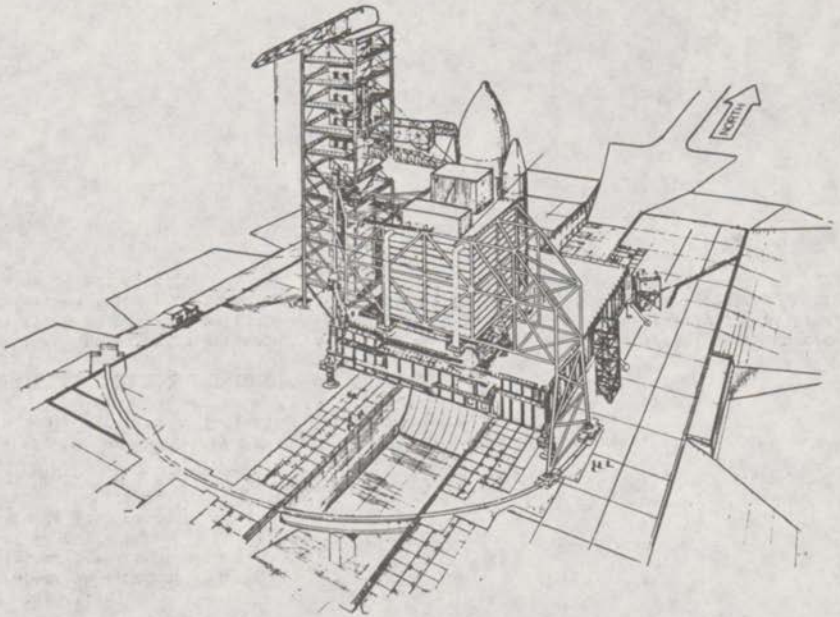


FIGURE 2

CF 10-12

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FISCAL YEAR 1980 ESTIMATES
MODIFICATIONS TO LAUNCH COMPLEX 39

CF 10-13

ROTATING SERVICE STRUCTURE
(Shown in Retracted Position at Launch Pad A)

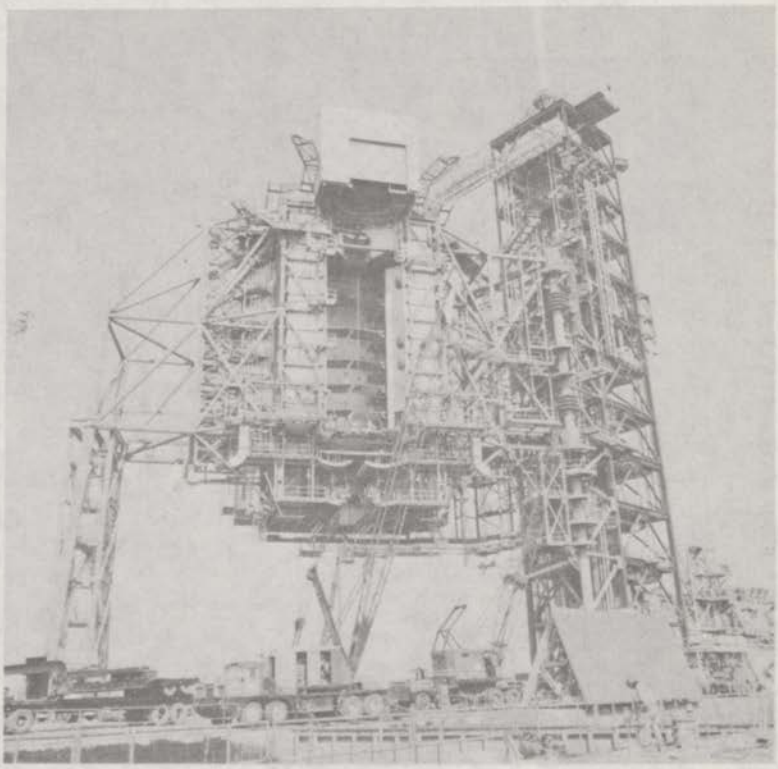


FIGURE 3

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FISCAL YEAR 1980 ESTIMATES
MODIFICATIONS TO LAUNCH COMPLEX 39

ROOF LAYOUT-LCC

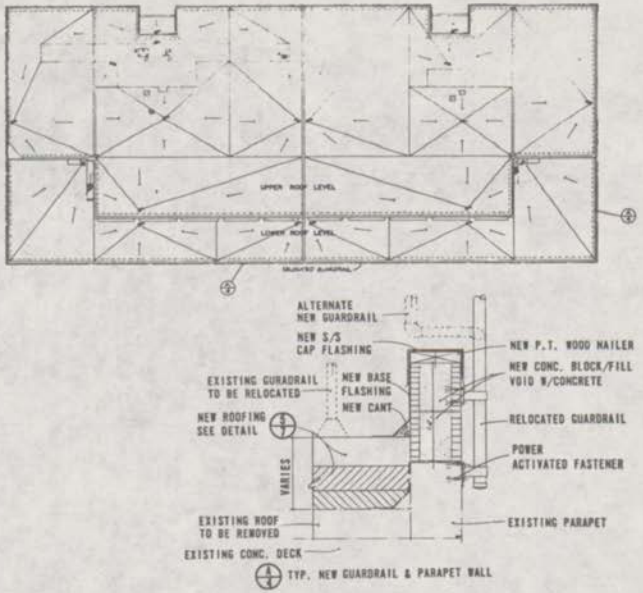


FIGURE 4

CF 10-14

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FISCAL YEAR 1980 ESTIMATES
MODIFICATIONS TO LAUNCH COMPLEX 39

RESOURCE REQUIREMENTS
(Millions of Dollars)

Item	Fiscal Year 1977 & Prior PP	1978 BR	1978 PP	1979 BR	1979 PP	1980 BR	Future BR	CCE
Launch Pad A	36.0	---	4.4	---	---	---	---	40.4
Launch Pad B	---	27.1	21.4	12.8	12.8	15.1	---	49.3
MLP-1	13.8	---	.5	---	---	---	---	14.3
MLP-2	9.5	4.9	4.8	---	---	1.1	---	15.4
MLP-3	---	---	---	---	---	---	---	17.6*
Vehicle Assembly Building (VAB)	7.9	8.7	9.6	---	---	---	---	17.5
Launch Control Center (LCC)	2.1	---	---	---	---	.6	---	2.7
Other	---	---	---	.8	.8	.9	---	1.7
Total	69.3	40.7	40.7	13.6	13.6	17.7	---	141.3

Note: PP = Program Plan
BR = Budget Request
CCE= Current Cost Estimate

* Not included in total; not a presently validated requirement.

FIGURE 5

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1980 ESTIMATES
MODIFICATIONS TO CRAWLER TRANSPORTER MAINTENANCE FACILITY
LOCATION PLAN

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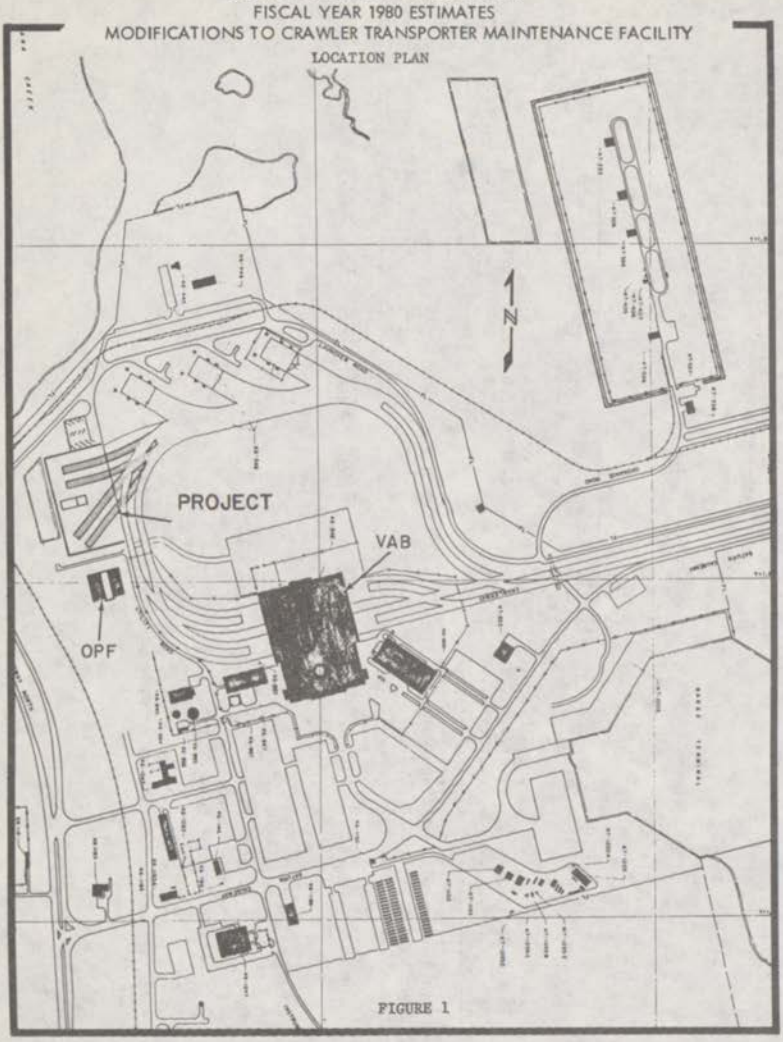


FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE:	Modifications to Crawler Transporter Maintenance Facility
INSTALLATION:	John F. Kennedy Space Center
FY 1980 CoF ESTIMATE:	$1,250,000

LOCATION OF PROJECT: Merritt Island, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Transportation Systems

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	92,500	---	92,500
Capitalized investment	N/A	46,220	46,220
Total	92,500	46,220	138,720

SUMMARY PURPOSE AND SCOPE:

The purpose of this project is to modify the present Crawler Transporter Maintenance Facility to provide sufficient maintenance and administrative areas to support the high level of maintenance for the two crawler transporters required to support the Space Transportation System launch schedule. The scope of work (as shown in Figure 2) will include grading the north area to improve drainage in wet weather, moving the Crawler Transporter (CT) parking positions, and relocating crawlerway extensions to be tangential to the centerline of the curved portion of the main crawlerway. Other tasks include relocating and modifying the steel support

building (K6-793), moving the northerly gate directly east, and building reinforced concrete servicing pits. Finally, utilities will be modified and extended and a parking lot with a new entrance will be constructed.

The two CT's used in the Apollo Program will be utilized to transport the Space Shuttle vehicles from the assembly site in the Vehicle Assembly Building (VAB) to the launch pad. The projected Shuttle launch schedule will increase the use and therefore the maintenance of the CT's to an extent far greater than that necessary for the peak years of the Apollo program. With increased maintenance now necessary on a routine basis, the existing facilities are not adequate to support the projected level of activity. This project provides necessary facilities to allow a viable CT maintenance operation. Additionally, this facility will allow optimization of operation and maintenance procedures, thus reducing maintenance costs and improving quality control.

PROJECT JUSTIFICATION:

As the flight rate for the Shuttle grows, the number of round trips -- each one 6.8 miles (10.9 kilometers) -- the CT's will increase significantly. The CT's are unique and complicated transport vehicles; to perform their crucial function they must be maintained at the highest level of readiness. This difficult task can be achieved only by an intensive maintenance program. Such a program is possible only if adequate support facilities are also available. The most difficult of the CT maintenance tasks is replacement of the treads or the tread rollers that carry the load from the main frame of the truck. Presently, to replace either of these components, the only method available is to excavate a trench under the area involved, drop the damaged tread or tread roller, move it within the trench, and pick it up with a mobile crane. Because the increased flight schedule will cause more repairs, specifically developed maintenance pits are necessary in order to do this work in an efficient and timely fashion.

Hydraulic maintenance must be performed under clean, reasonably dust-free conditions; it is best supported by an overhead crane with a hook height of 25 feet (7.6 meters) for assembling or disassembling the long hydraulic units. Previously, these operations were performed on a short-term basis in available facilities, but all these facilities will be fully utilized for the Shuttle and payload programs and are not available.

Furthermore, an electrical test area is required for repair, checkout, and calibration of electrical components, and a quality control area is needed to check out tolerances and the condition of worn or repaired equipment. Additional space is also needed for engineering support as the need for it grows with increased CT activities and maintenance.

This project will provide a consolidated maintenance facility for the two CT's that will be essential in the Shuttle operational era. In late 1981 the Shuttle program will be moving into the operational phase with higher flight rates and an associated increase in required maintenance. It is currently planned that this

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facility be operational by late 1981. As construction and checkout of the facility are estimated to take 18 to 20 months, an early 1980 start is required.

IMPACT OF DELAY:

Delaying this project will seriously reduce the capability to perform the essential maintenance required to keep the crawler transporters operational for the launch rates projected. The risk associated with deferral is considered imprudent under these circumstances; accordingly, this project should not be delayed.

PROJECT DESCRIPTION:

The project will move existing Building K6-793 approximately one-tenth of a mile (0.2 kilometers) from its present location, to that shown in Figure 2. The building will then be modified and an addition added to provide maintenance space, a shop with an overhead crane, and additional administrative space. Reinforced concrete servicing pits will be constructed. Additionally, the area will be graded to improve drainage in wet weather, the CT parking positions will be moved, the crawlerway extensions will be relocated to be tangential to the centerline of the curved portion of the main crawlerway, utilities will be modified and extended as required, and a parking area will be provided.

Building K6-793 is a single-story, concrete and steel, industrial building. After the building is modified and the addition is added (as shown in Figure 3), it will be 187 feet (57.0 meters) long, 40 feet (12.2 meters) wide and 35 feet (10.7 meters) high. The gross area will be 7,880 square feet (733 square meters). Only one piece of transfer equipment is to be installed: a crane with a 25-foot (7.6 meters) hook height. All related equipment is included in the project cost.

PROJECT COST ESTIMATE:

The basis of this cost estimate is a Preliminary Engineering Report.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	1,250,000
Crawler maintenance building	LS	---	---	944,000
Structural	LS	---	---	(555,000)
Mechanical	LS	---	---	(182,000)
Electrical	LS	---	---	(137,000)
Utilities	LS	---	---	(70,000)
Service pits	EA	2	84,000	168,000
Crawlerway	SY	14,000	8.29	116,000
Paving	SY	1,500	14.67	22,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				1,250,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Proposed Maintenance Facility
Figure 3 - Modified Maintenance Building

OTHER EQUIPMENT SUMMARY:

No other equipment has been identified for use with this facility project.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

Additional funding for basic plant equipment is not anticipated. However, future modification work may be necessary to satisfy unique program requirements as they evolve.

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1980 ESTIMATES
MODIFICATIONS TO CRAWLER TRANSPORTER MAINTENANCE FACILITY

PROPOSED MAINTENANCE FACILITY

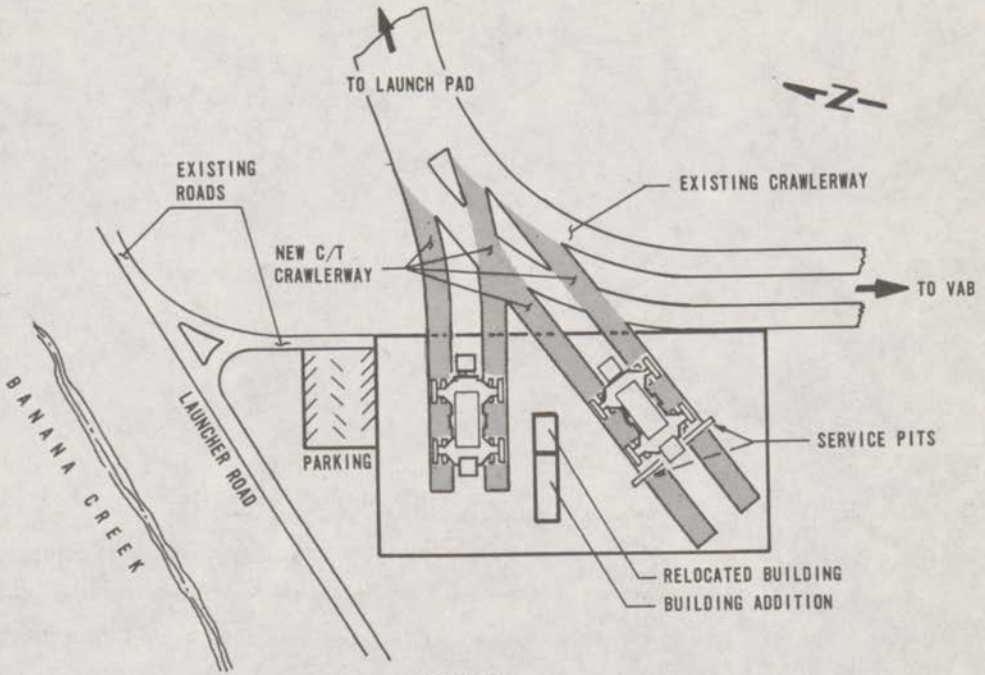


FIGURE 2

CF 10-22

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1980 ESTIMATES
MODIFICATIONS TO CRAWLER TRANSPORTER MAINTENANCE FACILITY

MODIFIED MAINTENANCE BUILDING

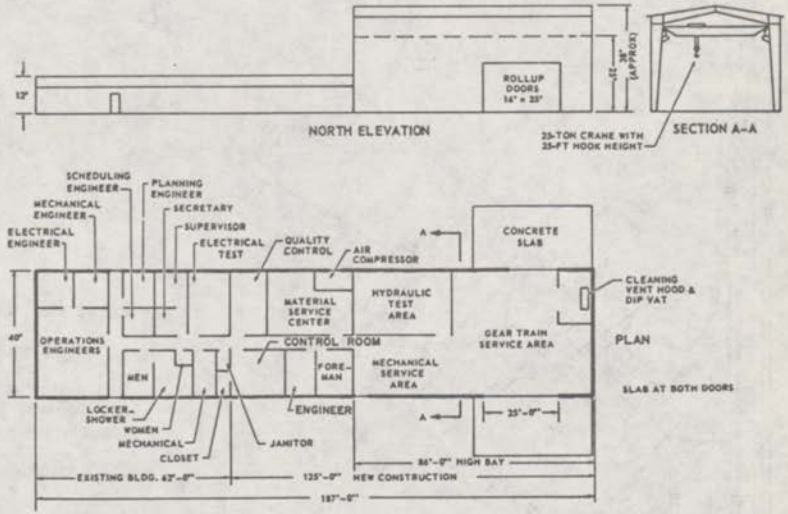


FIGURE 3

CF 10-23

MICHOUD ASSEMBLY FACILITY
FISCAL YEAR 1980 ESTIMATES
MODIFICATION OF MANUFACTURING AND FINAL ASSEMBLY FACILITIES
FOR EXTERNAL TANKS

LOCATION PLAN

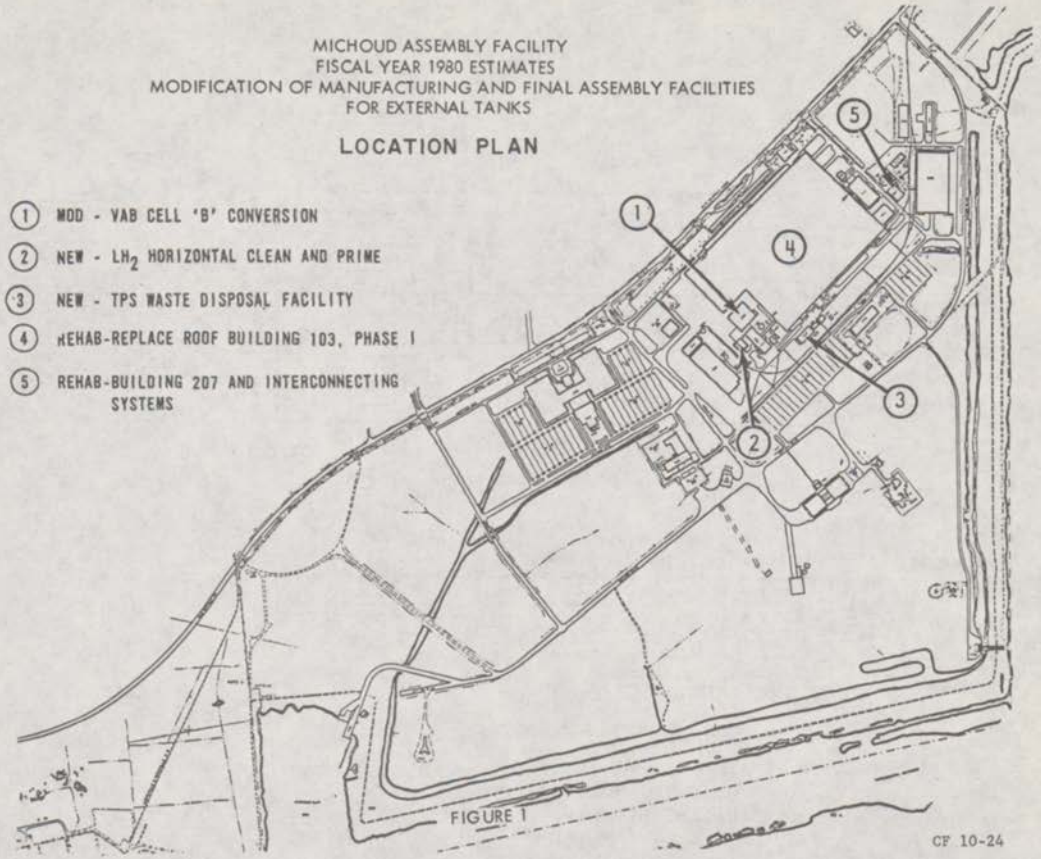


FIGURE 1

CF 10-24

PROJECT TITLE:	Modification of Manufacturing and Final Assembly Facilities for External Tanks
INSTALLATION:	Michoud Assembly Facility
	FY 1980 CoF ESTIMATE: $10,000,000

LOCATION OF PROJECT: New Orleans, Orleans Parish, Louisiana

COGNIZANT HEADQUARTERS OFFICE: Office of Space Transportation Systems

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	4,430,000	49,041,500	53,471,500
Capitalized investment	N/A	132,716,000	132,716,000
Total	4,430,000	181,757,500	186,187,500

SUMMARY PURPOSE AND SCOPE:

This project continues work begun with FY 1973 and other prior years resources, including FY 1979. This work involves the modification of manufacturing and final assembly facilities at the Michoud Assembly Facility (MAF) for the Space Shuttle external tank (ET) production. The external tank is an essential component of the space shuttle system in that it supplies propellants to the orbiter's main engines. Each ET consists of three major components: a liquid oxygen (LO_2) tank, an intertank and a liquid hydrogen (LH_2) tank. The prior year resources provided certain modifications to the Main Manufacturing Building, Building 103, the Vertical Assembly Building (VAB), Building 110 and the Final Acceptance and Checkout Building, Building 420; and construction

of Phase I, High Bay Addition, Building 114; a facility to apply ablator to the LH_2 Building 131, and a proof test facility for the LH_2 tank, Building 451. The overall facility work at Michoud is required to provide the facilities necessary to fabricate and assemble the three major components of the ET, test and clean them, apply a thermal protection system (TPS) to their surfaces, and assemble the major components into a complete ET. The tank is then equipped with plumbing and electrical systems, checked and approved, and shipped to the launch site where it will be mated with the orbiter and solid rocket boosters.

The FY 1979 project provided certain additional production facilities needed to support ET manufacturing and final assembly at a revised rate of 20-24 per year. Work to bring the utility plant and distribution system to a reliable level on a phased basis was also initiated.

This FY 1980 project provides for additional production previously planned and needed to be started now to provide the facilities to support ET production. It includes completing the LH_2 tank cleaning and priming cell in the building provided by the FY 1979 program and converting Cell "B" to its final production configuration. These projects have been done in stages to meet the requirements of production as it expands without overbuilding in the early years. Work has been phased so that construction will be completed in critical production areas before the production schedule becomes critical. This schedule should minimize interference between construction work and ET production.

One "new start" is also included in FY 1980. It will provide a complete facility to dispose of TPS wastes and handle other waste as well. Two added items are related to the integrity, reliability, and energy efficiency of the total plant and its basic support system. Repair of one half of the roof of Main Manufacturing Building, Building 103 (over the major ET production area), is included as a priority item. Additional modification and repair of the utility system to insure reliability is also essential.

PROJECT JUSTIFICATION:

The facility work included in the FY 1980 estimate for MAF involves the following projects:

a. Conversion of Cell "B" to its final production configuration at this time fits with other elements of the planned construction program. As cells in the High Bay Addition, Building 114, and the Horizontal LH_2 Ablator Spray Facility, Building 131, come on line, this cell can be converted from its initial production setup to a TPS foam spray cell for the LH_2 tank that is required to meet the production schedule as its companion, Cell "C", becomes overloaded.

b. Construction of the second phase of the Horizontal LH_2 Ablator Spray Facility includes outfitting the cleaning and priming bay within the facility. This phase of the work was originally planned as a cleaning

cell only, but a problem of cross contamination caused by performing priming of the LH_2 tank in the Horizontal Ablator Cell lead to the need for priming capability also.

c. Construction of TPS Waste Disposal Facility is scheduled to come on-line at a point in the production schedule when TPS wastes will be of such a volume that the current landfill method of disposal will no longer be acceptable. The new system will handle both the solids and liquids from the TPS as well as other wastes generated in the plant. The operating costs of the disposal system will be partially offset by savings in hauling the wastes outside the facility and use will be made of the heat generated to aid in plant power requirements.

d. Repair one-half of the roof of the Manufacturing Building 103. A recent storm has shown that the replacement of this roof cannot be delayed. During this storm, severe leaking of the roof occurred which was detrimental to production and would have had increased significance had production activities been at a higher rate. A recent survey of the roof showed excessive moisture exists throughout the roof system which requires replacement. In addition, moisture is penetrating the built-up roof at various locations in the complex drainage system over this large roof area. There is concern that, as the roofing work is performed, debris will fall into the production area and related damage can be minimized by completing work as soon as possible. The new roof will have an improved insulation value and will reduce energy consumption.

e. Rehabilitate the Boiler Plant, Building 207, and the supporting utility system. The first major effort to improve efficiency and reliability of the utility system came with the inclusion of the replacement of the chillers in the FY 1979 budget. This follow-on work is the next planned step in an overall effort to provide a utility system that will support ET production through the late 1980's. It includes rehabilitating the main steam condensate distribution system, modifing parts of the electrical distribution systems, providing backup fuel storage and ability to operate on Number 5 and 6 fuel oils, and rehabilitations within the central boiler plant.

VAB Cell "B", Building 110

Cell "C" is currently being utilized for manual ablator bonding on the LH_2 tank as well as forward dome and barrel spray foam operations. After the planned offload of ablator operations to the horizontal spray facility, Cell "C" will be devoted to spray foam operations and will attain a production rate of 20 LH_2 tanks/year in the early years. As the learning process improves, it will eventually accommodate 30 tanks/year. During the time frame when Cell "C" has not reached a rate of 30 LH_2 tanks/year, Cell "B", is required to support production of LH_2 tanks at a rate greater than 20 per year. In the early years, Cell "B" and "C" will have a combined spray foam capability of 40 LH_2 tanks/year which could ultimately increase to 60 LH_2 tanks/year with experience.

Due to the interference generated by having construction subcontractors in the VAB facility while production is going on, it is advantageous to perform the cell conversion while the ET production rate is still low.

LH_2 Horizontal Clean and Prime Position, Building 131, Phase II

Presently, Cell "E" in the VAB is the cleaning cell for both the interior and exterior of the various major ET components. As activities and the production rate in the VAB increase, the cleaning capability and logistic activities associated with this function become saturated. As forecast in the FY 1979 project, a second cleaning position is required for the exterior of the LH_2 tank which will significantly reduce the load on Cell "E". Addition of this facility will result in less use of deoxidizer in Cell "E", thereby prolonging the cell's effective life and reducing maintenance problems. It will also reduce the risk of a "program shutdown", which would result if Cell "E" fails because it is a one-of-a-kind facility. The addition of a primer capability to this cleaning cell effectively eliminates the possibility of silicone cross-contamination which can occur if primer and ablator operations are combined in the ablator cell.

TPS Waste Disposal System, Building 105

TPS waste (solids and liquids) will continue to increase through the life of the ET project. The excessive volume and amount of waste material dictates specialized disposal which MAF is not now equipped to handle. As a minimum, the production phases will generate over 60,000 cubic feet of TPS waste annually. Long term storage of waste is costly, impractical and does not reduce the requirement for disposal. This facility will also handle other waste generated at the plant. The volume of waste generated as production increases, will no longer make the current landfill method of disposal cost effective or acceptable.

Rehabilitate Roof, Building 103, Phase I

Building 103 was constructed in 1943 and completely reroofed in 1963. Major roof rehabilitations were performed during 1965, 1969, and 1972. Since the initial rehabilitation, the roof has been patched and repaired but there are still continuous leaks and soft spots where insulation is saturated and blistered due to trapped moisture. Manufacturing operations are often disrupted due to leaking water. To correct these problems and to preserve the roof structure this roof should be replaced. Replacement of the roof will also improve the energy profile of the plant with the replacement of the insulation system. This project is Phase I of two phases and would encompass half of the approximately 1,800,000 square feet (167,200 square meters) of Building 103, and would be primarily devoted to the solution of the roof problem over the manufacturing areas.

Rehabilitation of Building 207 and Interconnecting Utility System

Building 207 is the main boiler house and it, along with the utility system of the Michoud Assembly Facility, was constructed in 1943. Numerous repairs have been made over the past three years on a spot basis.

The following items are included:

a. Rehabilitation and Replacement of Steam Condensate System and HVAC Distribution System, Building 103

The steam condensate system is 25 years old and is a part of the environmental control system for the main manufacturing building supporting External Tank production. Presently, the system has developed numerous leaks that are beginning to seriously affect production. Also included in the project is work to seal up the 42 roof fan houses and provide better control for improved energy efficiency.

b. Modify Electrical Distribution System

Modification to selected, existing transformer substations will provide increased load capacity and ability to switch load between substations to prevent production shutdown in the event of the failure of one the these transformers. Changes in the feeder system to the substation will increase the reliability of the system.

c. Rehabilitate Motor Control Center (MCC), Building 207

The motor control center provides electrical service to the boiler plant condenser water pumps #1 through #6. These pumps are necessary for continuous operation of the MAF Boiler Plant which supplies environmental control for External Tank production areas. The motor control center components are obsolete and replacement parts are unavailable. In addition, the unit requires excessive maintenance (i.e., 265 man-hours in 1977).

d. Modify MAF Boiler Plant for Number 5 and Number 6 Fuel Oil Capability

The prime source of fuel for the MAF Boiler Plant is natural gas which MAF has been advised may be severely curtailed. The backup source of fuel for MAF is Number 2 oil which is also in short supply. This proposed boiler plant modification will permit use of Number 5 or 6 heavy grade oils in the event natural gas or Number 2 fuel oil cannot be obtained. A curtailment of usable fuels would necessitate shutting down the boiler plant. This act would result in loss of the plant HVAC system and an unacceptable degradation of the controlled environment required for space hardware fabrication, assembly, and storage activities.

e. Construct 500,000-Gallon Fuel Oil Tank and Dock Facility

Existing reserve capabilities of fuel oil at MAF will allow for approximately 3 weeks continuous operation of the MAF boilers. These boilers provide environmental control (heating, backup cooling, and humidity) to the main External Tank manufacturing building. Installation of a second 500,000-gallon storage tank will provide added reserve capability, and an offloading dock facility will allow the tanks to be supplied by barge. As with the previous items, failure to have usable fuel available would stop operations at MAF. This system will accommodate Number 5 and 6 fuel oil.

f. Modify Platforms and Other Safety Modifications

This item modifies the main boiler plant to conform to OSHA standards for access platforms, stairs, machinery guards and pipe identification.

g. Rehabilitate Building 207, Structure and Roof

As with the utility systems it houses, the building shell itself needs to be rehabilitated. Doors are deteriorated, hinges are corroded, many windows are defective, and mechanical controls on the windows are defective and inoperable, and some drain systems require rerouting. The basic roof is over 35 years old and in poor condition. In addition to storm damage, it has been penetrated during early equipment installation. This project is phased to be completed with the major work on the utility system.

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IMPACT OF DELAY:

The LH_2 Horizontal Clean and Prime Position and VAB Cell "B" conversion are required to support production rate capability. Failure to provide them at this time will affect the ability to manufacture ET's to support flight rates in the 1982-1983 time frame. The TPS Waste Disposal System, if not provided, creates the problem of disposing of TPS and other waste by more costly hauling off-site and landfill techniques. Failure to replace the roof of Building 103 and to rehabilitate Building 207 and the interconnecting utility system would, because of water damage or loss of vital utilities, seriously impact production.

PROJECT DESCRIPTION:

This project continues work authorized in prior years. It includes constructing modifications to Buildings 103, 110 and 207; adding a cleaning and priming position to the LH_2 Horizontal Ablator Spray Facility; modifying Building 105 to house a TPS Waste Disposal Facility; rehabilitation of Building 207 and its connected utility system; and rehabilitation of one-half of the roof of Building 103.

Modify VAB Cell "B", Building 110

Cell "B" of the VAB will be converted from an LO_2 tank and intertank TPS position to an LH_2 tank position for applying foam on the forward dome and barrel. This conversion requires changing air-conditioning and heating ducting, changing interface utility connections, modifying tool installation interfaces, and providing additional doorways and access platforms.

Construct LH_2 Horizontal Clean and Prime Position, Building 131, Phase II

This project is a continuation of the FY 1979 project for a Horizontal Ablator Spray, Phase I (as shown in Figures 2 and 3). It provides the capability of accepting the LH_2 tank in a horizontal position for exterior cleaning, deoxidation, and application of primer. The entire cleaning process will be semi-automatic; it will be controlled through pushbutton operations in the control room. The primer application will be carried out by a numerically controlled spray system. Specifically provided is the outfitting of the cell, which includes special wall and floor finishes, miscellaneous foundations for pumps, etc., and concrete and structural steel for pipe racks. Mechanical and electrical equipment for cleaning and priming is also installed.

Modify for TPS Waste Disposal Facility, Building 105

MAF Building 105 will be modified and equipped with a disposal unit capable of the incineration of liquid and solid TPS waste, industrial waste, and garbage. A layout of this facility is shown in Figure 4. It includes the installation of a pipeline from Building 103 to 105 for disposal of MEK/HEPTANE-contaminated water. Gas or fuel oil burn incineration will be possible. Incinerator heat will be used when possible to generate steam for space heating and processes.

Rehabilitate Roof, Building 103 Phase I

This project provides for the removal of existing roofing (shown in Figure 5) and the installation of an asphalt, built-up, 4-ply roof with insulation, flashing, expansion joint covers, pitch pockets etc., over the concrete tile deck. Also included is the elimination of all unnecessary roof openings and the rehabilitation or replacement of vents and hatches. This project is Phase I of two phases; it will encompass approximately one-half of the 1,800,000 square feet (167,200 square meters) of Building 103's roof area.

Rehabilitate Building 207 and Interconnecting Utility Systems

This project consists of rehabilitation and modification of the main boiler plant at Michoud Assembly Facility, Building 207. Work involves installing new doors, caulking and re-glazing windows, reworking window control mechanisms, modifying drain systems, replacing defective structural members, and removing and replacing broken concrete blocks and bricks of the exterior walls. The interconnected utility systems consist of the following:

a. Rehabilitate Steam Condensate System and HVAC Distribution System of Building 103. The work consists of replacing in part 6,000 feet (1,829 square meters) of insulated pipe and repairing insulation on the remaining pipe. The majority of this pipe is located above the 40-foot (12 meters) level in the Main Manufacturing Building 103. This project also provides for replacing miscellaneous valves, pipe hangars, fittings, and traps, and rehabilitating steam condensate stations. Also included are sealing and other efforts to improve the efficiency of the plant's roof fan houses.

b. Modify Electrical Distribution System. This project increases the capability and provides load shifting ability at eight transformer substations and load transfer only at two substations. The addition of two feeder lines and the rehabilitation and modification of two feeder lines will service five substations and one master station to enhance reliability of the electrical system.

c. Rehabilitate Motor Control Center, Building 207. This project provides for replacing the existing motor control center for Substation #13 at the MAF Boiler Plant which provides service to six boiler plant condenser water pumps.

d. Modification of MAF Boilers for #5 and #6 Fuel Oil Capability. These modifications involve changing burners, internal fuel oil piping, day tank storage systems, and boiler control system; adding air pollution control equipment; and providing steam supply lines, condensate return lines, and steam trace lines on the piping system connecting the fuel oil storage tank farm area required to handle Number 5 and 6 fuel oil.

e. Construct 500,000-Gallon Fuel Oil Tank and Dock Facility. These modifications involve installing a second 500,000-gallon storage tank with heater and steam coils, electric lights and connecting piping. Also included is the construction of a dock on the Michoud canal for unloading two barges and a transfer line from the dock to the storage tanks, with necessary steam and electrical power lines.

f. Modify Platforms and Other Safety Modifications, Building 207. This project provides for properly identifying all piping; installing OSHA standard access platforms for valves and fitting; installing new stairs and ladders; and installing safety guards, rails, and shields.

g. Rehabilitate Building 207, Structure and Roof. This project consists of rehabilitating the main boiler plant at MAF. Work involves installing new doors, caulking and reglazing windows, reworking window control mechanisms, changing the drain system, replacing defective structural members and removing and replacing broken concrete blocks and bricks of the exterior wall. The existing roof (17,000 square feet (1,580 square meters)) will be removed and replaced with an aggregate surfaced asphalt built-up, 4-ply roof with insulation over the existing deck. Also included will be the rehabilitation or replacement of vents and hatches.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	10,000,000
Modifications to the vertical assembly building	---	---	---	800,000
Cell "B" conversion	LS	---	---	(800,000)
Construction of LH_2 tank clean and prime facility	---	---	---	2,700,000
Foundations	LS	---	---	(140,000)
Process heating and air-conditioning	LS	---	---	(450,000)
Fire protection systems	LS	---	---	(110,000)
Mechanical systems	LS	---	---	(1,790,000)
Utility systems	LS	---	---	(210,000)
Site work	LS	---	---	---
Construction of TPS waste disposal facility	LS	---	---	900,000
Rehabilitation and modification of building 207 and rehabilitation of interconnecting utility system	---	---	---	2,500,000
Replace roof building 103	SF	900,000	3.44	3,100,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				10,000,000

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LIST OF RELATED GRAPHICS:

Figure 1 - MAF Location Plan
Figure 2 - LH_2 Horizontal Clean and Prime Facility, Building 131
Figure 3 - Modifications and Additions
Figure 4 - Plan Layout, TPS Waste Disposal Facility, Building 105
Figure 5 - Roof Rehabilitation, Building 103

OTHER EQUIPMENT SUMMARY:

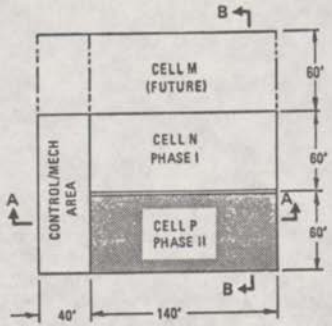
Special tooling (e.g., spray tooling, assembly tooling, unique work platforms, and special dollies) will be needed to meet initial operations. They will be funded from R&D sources. Existing additional Apollo tooling, with modifications as required, will be used to the maximum extent possible.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

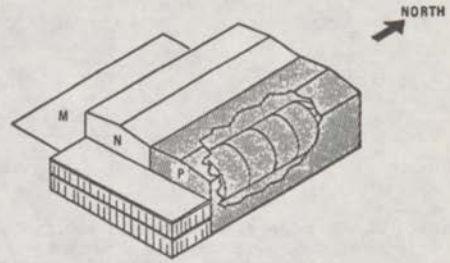
Some $14 to 17 million of CoF resources may be required in the future to provide storage for a minimum of eight completed External Tanks, two additional TPS cells for the LO_2 and Intertank in Building 114, more storage capacity for demineralized water, an additional Tank Ablator Spray Cell, a chemical tank foam recovery system, a second Final Acceptance and Checkout Station, and the second and final phase of replacing the roof of Building 103. Additional modification work may also be necessary to satisfy future programmatic requirements as they may evolve.

MICHOUD ASSEMBLY FACILITY
FISCAL YEAR 1980 ESTIMATES
MODIFICATION OF MANUFACTURING AND FINAL ASSEMBLY FACILITIES
FOR EXTERNAL TANKS

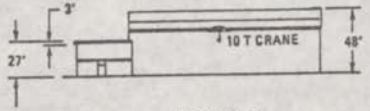
LH_2 HORIZONTAL CLEAN AND PRIME FACILITY,
BUILDING 131



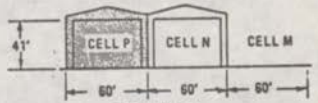
LAYOUT PLAN



PERSPECTIVE



SECTION A-A



SECTION B-B

FIGURE 2

CF 10-36

704

MICHOUD ASSEMBLY FACILITY
FISCAL YEAR 1980 ESTIMATES
MODIFICATION OF MANUFACTURING AND FINAL ASSEMBLY FACILITIES
FOR EXTERNAL TANKS
MODIFICATIONS AND ADDITIONS

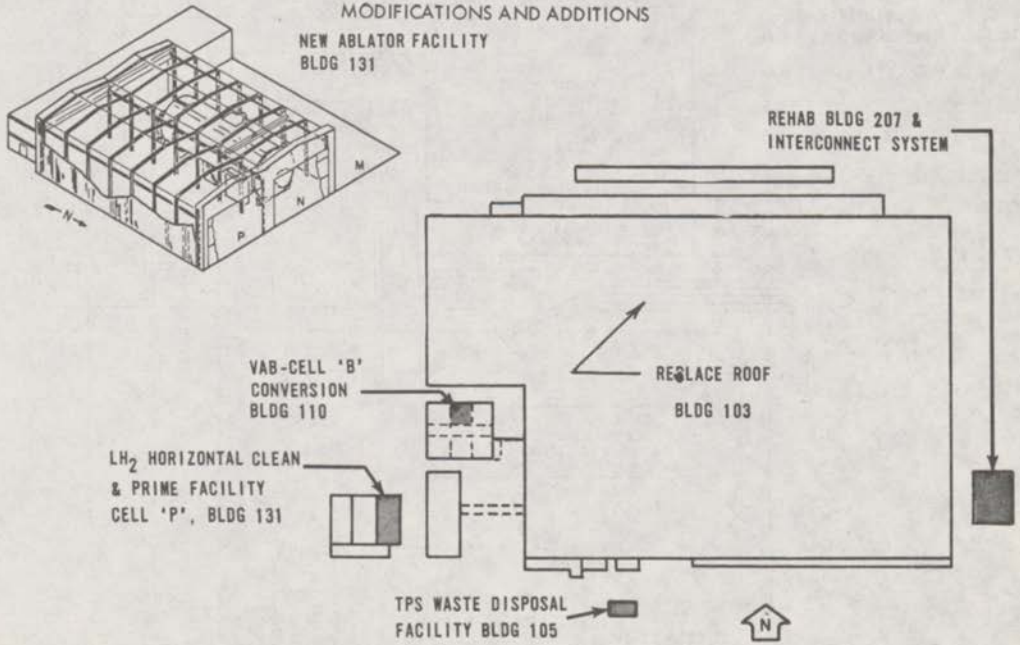


FIGURE 3

CF 10-37

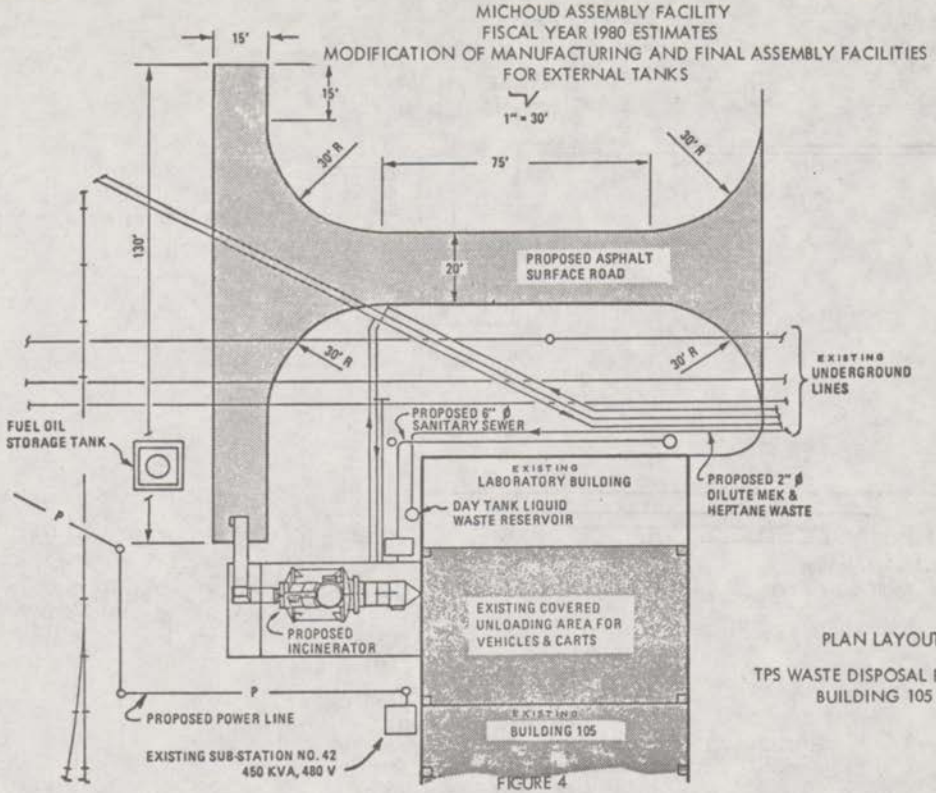


FIGURE 4

PLAN LAYOUT,

TPS WASTE DISPOSAL FACILITY,
BUILDING 105

CF 10-38

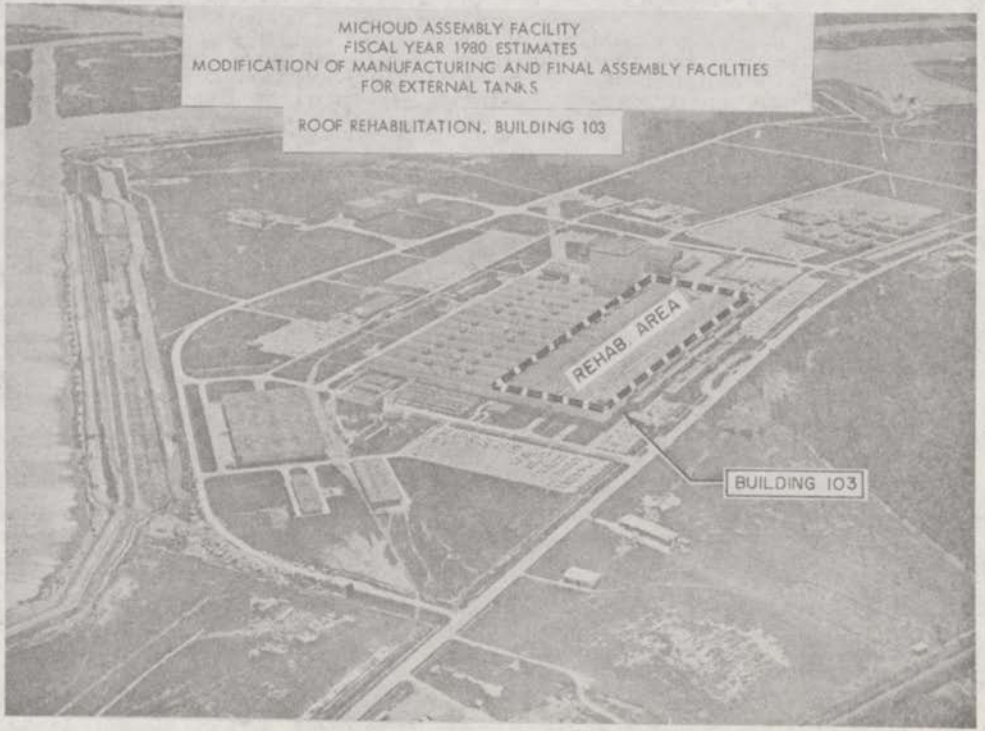


FIGURE 5

CF 10-39

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE: Minor Shuttle-Unique Projects

INSTALLATION: Various Locations

FY 1980 CoF ESTIMATE: $2,500,000

LOCATION OF PROJECT: Various Locations

COGNIZANT HEADQUARTERS OFFICE: Office of Space Transportation Systems

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	602,000	*6,210,000	6,812,000
Capitalized investment	N/A	**1,565,000	1,565,000
Total	602,000	7,775,000	8,377,000

*CoF Minor Shuttle-Unique Projects
**R&D/R&PM Minor Shuttle-Unique Projects

SUMMARY PURPOSE AND SCOPE:

The purpose of this project is to provide for minor rehabilitation and modification of facilities necessary to support the Space Shuttle Program at NASA field installations. Included in this project are facility rehabilitation and modification projects estimated to cost less than $500,000 and minor construction projects estimated to cost less than $250,000. These projects are unique requirements of the Space Shuttle Program to achieve initial operational capability or to meet program milestones.

PROJECT JUSTIFICATION:

Space Shuttle development, assembly, and test requirements are being carried out to a large extent in existing Government facilities at the various NASA installations and industrial plants. The major modifications and new construction required at these locations are presented as discrete line items within an integrated Space Shuttle facilities project. In many instances, Shuttle support can be accommodated in existing facilities, or when only limited rehabilitation or modification is required to achieve the desired capability.

This project includes only Shuttle-unique facility rehabilitation and modification projects estimated to cost less than $500,000 and minor construction projects estimated to cost less than $250,000. Each work item is necessary to support a specific Shuttle requirement, insure continued reliability, provide a safer environment, and/or improve the efficiency and economy of individual facilities supporting the Space Shuttle Program.

For clarity, full disclosure purposes, and better fiscal and technical control, all unique Space Shuttle facility requirements, both discrete individual line items and the smaller facility projects, are included in the total Space Shuttle CoF budget. The work covered in this project is of such a nature and magnitude that it is included under a single rehabilitation and modification Shuttle project for various locations. The cost of this project and all similar follow-on projects will be charged against the total Space Shuttle facilities commitment.

PROJECT DESCRIPTION:

This project provides for necessary unique rehabilitation and modification to existing facilities and minor construction in support of the Space Shuttle Program. The justification, description, and cost estimate for each element are listed below:

A.	Johnson Space Center (JSC)	225,000
1.	Modifications of Mission Control Center, Building 30	225,000

This project is required to further reconfigure the Mission Operations Wing (MOW) and lobby wing of Building 30, Mission Control Center, for the Space Shuttle operational phase. It provides for modifications within approximately 6,950 square feet (646 square meters) on the second and third floors of the MOW, and 3,800 square feet (353 square meters) on the second floor of the lobby wing. The work includes reconfiguration of

interior partitions, replacement of suspended ceiling, and replacement of damaged raised flooring. Also included are modifications to lighting, electrical power distribution, air-conditioning and fire detection and supression systems. The MOW of Building 30 was originally designed for single mission capability. As the flight rate increases in the Shuttle operational phase, the second and third floors of the MOW must be configured to accommodate simultaneous support of multiple Shuttle flights and payloads. The modifications on the second floor of the lobby wing are required to meet additional configuration changes to support Shuttle operations.

B. Dryden Flight Research Center (DFRC)..... 490,000

1. Rehabilitation of Microwave Scanning Beam Landing System Cabling..... 490,000

Permanent installation of the Microwave Scanning Beam Landing System (MSBLS) at Edwards Air Force Base is required by October 1980 in order to support the Secondary Landing Site concept for contingency Space Shuttle landings. After the early Space Shuttle developmental test flights are completed, the existing MSBLS equipment will be relocated from runway 17/35 at the lakebed to runway 04/22 for permanent installation. The existing inter-site control and monitoring cabling has been subjected to vehicular traffic and the normal debilitating effects of a desert-like environment. This cabling was not planned to be permanent, and is not direct burial cable. Resources from this project will be used to procure and install some 30,000 linear feet of audio wide-band cabling for control and monitoring of the MSBLS.

C. Marshall Space Flight Center (MSFC)..... 1,440,000

1. Modify Major Component Clean Facility, MAF..... 490,000

The major component clean facility at Michoud Assembly Facility (MAF) is an existing Apollo facility that has been converted for the use of cleaning major External Tank components prior to assembly operation. The facility and its supporting utilities and equipment is over fifteen years old and is in need of modification and repair. The present floor lining must be removed and the subfloor resealed with a special chemical repellant sealant and a curbing system installed to retain chemical spills. The associated utilities and equipment will be refurbished to lessen the potential for breakdown. A more powerful and corrosive cleaning solution than originally planned is now used in this facility. These modifications will provide adequate protection against corrosion essential to continued operation of this one-of-a-kind facility.

2. Modify "Missile Grade" Air, Building 420, MAF..... 360,000

At the present time, gaseous nitrogen (GN_2) is used to purge the Intertanks and Liquid Hydrogen (LH_2) tanks prior to shipment from MAF. This purge operation takes place in Building 420. By providing the capability

to purge these tanks with "missile grade" air (clean/filtered compressed air), the use of the present nitrogen system and its associated safety hazards can be eliminated. In addition, this project will produce an estimated savings of $1,500 (1977 prices) per External Tank (ET) by eliminating the need for GN_2. The project includes activating two large existing air compressors in Building 111. Piping will be installed from Building 111 to Building 420 to connect the compressors to the purge system. The existing GN_2 system will be tied-in as a backup.

3. Modify Cell "E" for Cleaning Environment, MAF..... 290,000

Due to the debonding problem of the Thermal Protection System primer on tanks produced early in the cycle, it became necessary to go to a more vigorous cleaning solution. Aerowash "A" has been replaced with a deoxidizer. This change created a requirement to protect the cell equipment exposed to this deoxidizer. This includes protecting or replacing lighting fixtures, exhaust ducts and fans, instrumentation panels and tubing, and adding new exhaust scrubbers for environmental protection. An additional portion of the distribution and storage system used for the cleaning solution must be replaced or protected.

4. Install Monorails and Bridge Cranes, MAF..... 300,000

These overhead cranes are required to support production operations in the Assembly of hardware on the External Tank, horizontal final assembly positions 3 and 4. This additional capability is necessary to support production of ET's beyond a rate of 24 per year. Providing for the construction during this fiscal year ensures timely completion of construction activity in Building 103 prior to achieving a high production rate, thereby reducing the possibility of additional contractor cost to compensate for work interruption and eliminating interferences with ongoing critical production operations. It includes two 2-ton and two 3-ton cranes and the associated bridge and trolley system. The 2-ton cranes are mounted at the bottom chord of the roof structure with 200 feet of rail. The 3-ton cranes are mounted in the roof truss system with approximately 50 feet of rail. This project will handle the ET into, during processing, and out of horizontal positions 3 and 4.

D. Kennedy Space Center (KSC)..... 345,000

1. Modifications to Lighting in Vehicle Assembly Building (VAB)..... 210,000

This project provides for modifications to the 1286 mercury vapor lamps in the high and low bay areas of the Vehicle Assembly Building (VAB). 570 lamps will be permanently disconnected and removed, and 510 fixtures in the transfer aisle of both the low and high bay areas will be respaced to provide 37 foot candles of illumination at the center line of the transfer aisle. In the four high bays, all mercury vapor lamps below the 192 foot level will be removed and replaced with the sodium vapor lamps. They will be spaced to provide

10 foot candles on the Mobile Launcher platform in high bays 1 and 3, and 37 foot candles at the center line of the floors in high bays 2 and 4 to support SRB operations. The lamps will be capable of selective switching to provide 5 foot candles when vehicle operations are not in progress. The mercury vapor lighting system in the VAB exceeds the area coverage and the light levels required to support the Space Transportation Systems operations for the future, and is less energy efficient than present day fixtures. By redesigning and implementing the lighting system, this project will produce energy savings of 46.815×10^9 BTU's per year, resulting in a 1.21 year payback period.

2. Rehabilitation and Modification of Demineralized Water Facility..... 135,000

This project provides for the replacement of the existing manually operated, 1.5 million gallons per year, demineralized water production units with new semi-automatic, 3.0 million gallons per year units at Launch Complex 39 and replacement of the inter-connecting pipe system. An annual requirement of almost 3.0 million gallons will be required to support peak Space Shuttle activities, principally in the field clean and pre-clean rooms (1,900,000 gallons), SRB Disassembly Facility (800,000 gallons) and the chemical analysis laboratory (100,000 gallons). Also included will be the installation of a 10-foot by 20-foot canopy/roof over the units to protect them from the elements. Maintenance of the existing system is costly, and spare parts are not available. Replacement of the existing piping system is necessary at an early date, and this costly work should be integrated to fit with the larger and demineralized water production units. The new semi-automatic system will result in a reduction of the cost of demineralized water production from $.0179 per gallon to $0.0100 per gallon, thereby paying for the unit in six years.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

SUMMARY

SPACE SHUTTLE PAYLOAD FACILITIES

	Amount	Page No.
Office of Space Science:		
Rehabilitation and modification for payload ground support operations (KSC)	2,610,000	CF 11-1
Modification of and addition to materials sciences laboratory (ARC)	1,640,000	CF 11-13
Total	4,250,000	

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1980 ESTIMATES
REHABILITATION AND MODIFICATION FOR PAYLOAD GROUND SUPPORT OPERATIONS
LOCATION PLAN

CF 11-1

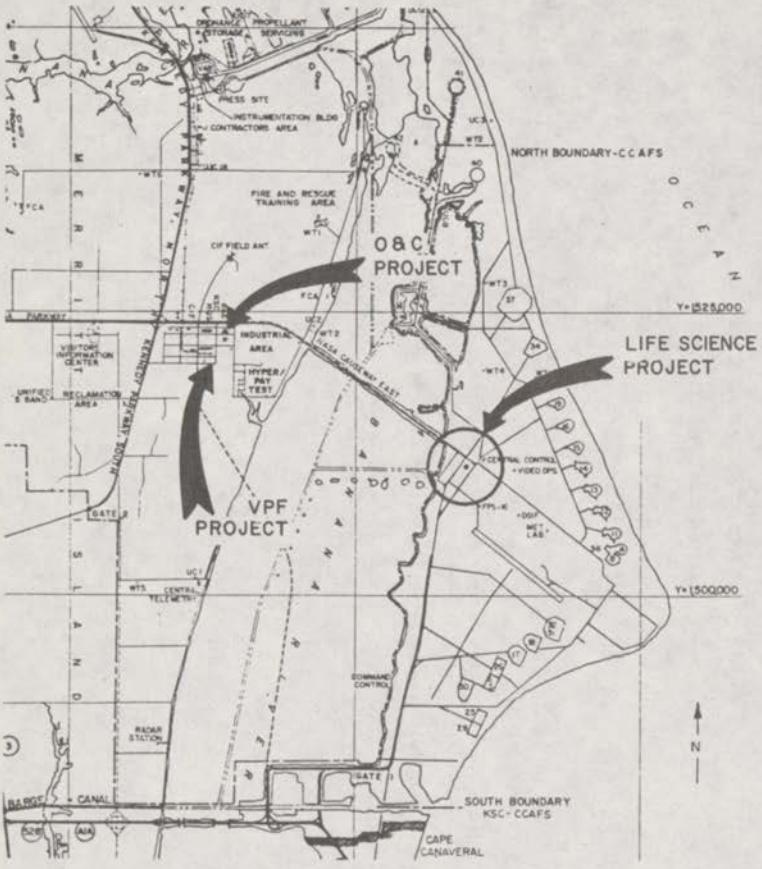


FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE:	Rehabilitation and Modification for Payload Ground Support Operations
INSTALLATION:	John F. Kennedy Space Center
FY 1980 CoF ESTIMATE:	$2,610,000

LOCATION OF PROJECT: Merritt Island, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Transportation Systems

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	1,113,568	9,980,000	11,093,568
Capitalized investment	N/A	48,357,348	48,357,348
Total	1,113,568	58,337,348	59,450,916

SUMMARY PURPOSE AND SCOPE:

The purpose of this project is to provide for rehabilitation and modification of facilities necessary to support Space Shuttle payload ground operations at the NASA launch site, Kennedy Space Center. Included in this project are major discrete projects and facility rehabilitation and modification projects estimated to cost less than $500,000. These projects are requirements in support of the Space Shuttle payload program. This project continues modifications to the Operations and Checkout (O&C) Building, and the Vertical Processing

Facility begun with FY 1977 and FY 1978 resources. In addition, it provides for modifications to the Missile Assembly Building (Hangar L) located at Cape Canaveral Air Force Station (CCAFS), Florida, to accommodate Integrated Life Sciences Operations.

PROJECT JUSTIFICATION:

Space Shuttle Payload Ground Support Operations will be carried on at NASA's launch site, KSC. Many different facilities will be involved in payload support operations, requiring both major (discrete) and minor construction, and facility rehabilitation and modification. For the purposes of clarity, full disclosure, and better technical and fiscal control, it was thought best to now include all payload ground support projects at KSC in one category.

The Space Transportation System (STS) operational phase of the Space Shuttle program will commence after the first six development flights in CY 1979 and CY 1980. At this time the primary purpose of the STS will be in the support of payload operations. FY 1977 resources provided for modifications to the O&C Building for the horizontal processing of Spacelab payloads and other classes of payloads while FY 1978 resources provided for the vertical processing of the Inertial Upper Stage (IUS), the Spinning Solid Upper Stage (SSUS), and other payloads in the former Spacecraft Assembly and Encapsulation Facility (SAEF-1), now called the Vertical Processing Facility (VPF).

This project provides for additional modifications to the O&C Building to support Spacelab Payload Level IV integration. Level IV integration is that work needed to place experiments in racks, and buildup and integrate racks and pallets for further integration into the Spacelab. This is a new requirement for KSC that did not exist at the time the FY 1977 project was requested. An intensive NASA study has recently concluded that substantial savings, primarily in transportation costs, can be achieved if Level IV "hands on" Spacelab payload integration is done at the launch site (KSC) rather than at field Centers or other government or industry locations where the experiments are developed. Prior to Shuttle missions, payloads will be shipped to KSC and received, processed and checked out in off-line locations other than the O&C Building. These payloads will then be brought to the O&C Building for integration and checkout in the Spacelab hardware. Specifically, the work included in this project will modify the area in the O&C Building dedicated to this Level IV activity. Previous modifications to the O&C Building provided the capability for functions associated with final assembly and checkout of the Spacelab and disassembly following completion of a Shuttle mission.

Also included in this project are resources to continue modifications to the Vertical Processing Facility (VPF) to support vertical payload integration. When this specific project was submitted in FY 1978, the crane capacity of the existing facility (SAEF-1) was thought to be adequate for all known payloads. Since then however, the weight of the IUS vehicle has increased considerably and future planning now includes missions

that require twin stage IUS's. The individual IUS's will be integrated into a twin stage configuration in the workstands in the VPF, and once in this mode, must be lifted together in a strongback for certain NASA missions. The existing crane in the VPF has only 25 tons of capacity and must be upgraded to 35 tons to lift twin or twin + spinner stage IUS vehicles. The first requirement for this increased crane capacity is for the Galileo mission presently scheduled for early CY 1982. In order to support this mission, fabrication and installation must be accomplished prior to October 1981, thus an FY 1980 project is essential.

Resources will also be provided for a Life Sciences Support Facility. This facility will be used to house animal/biological specimens for preflight conditioning and selection, and to provide a research lab capability for Principal Investigators to conduct preflight specimen preparation, and synchronous ground control experiments during flight. In addition, it will be used to perform post-flight analyses of flight and control specimens and to allow preparation of experiments for payload integration. At the present time no permanent facility capability exists to support extensive Life Science missions. In previous programs, Life Science requirements were of such a reduced magnitude that they could be satisfied by temporary facilities such as trailers. In the Space Shuttle era, Life Science payloads are planned as routine with both dedicated Life Science missions, or Life Science experiments flying alongside other Spacelab experiments. Each dedicated payload mission will involve 20-45 experiments and 20 principal investigators. Housing for up to thirty primates and 500 rodents per specific mission will be required. This facility will also provide holding areas for plants, fish and amphibians, and cells and tissues.

It is highly desirable to locate this facility close to the launch site as it is not scientifically feasible to perform the required operations at any great distance from the launch site. Preflight conditioning requires specimens to be as stabilized and quiescent as possible before lift-off. Hangar "L" at CCAFS (adjacent to KSC) was selected for this facility because it is available for use and close to the launch pad. Studies have indicated that the required modifications to this facility will be most cost effective when compared to those required for other candidate facilities. The Life Sciences Support Facility is required in FY 1980 in order to allow sufficient construction and activation time to meet a required facility Operational Readiness Date (ORD) of July 1981. This requirement is based upon the need for specimen delivery to Kennedy Space Center at least one month prior to the first dedicated Life Sciences mission, currently scheduled for late fall 1981.

IMPACT OF DELAY:

The Level IV integration of payloads into the Spacelab hardware can be accomplished at other NASA Centers than KSC, but at a definite higher cost penalty. To operate in this mode is very expensive, due to the need to ship Spacelab flight hardware to and from the launch site and the duplication of equipment and facilities. In order to accomplish modifications to the O&C Building prior to major Spacelab operations, and thus minimize the impact of construction on these critical operations, these modifications are required in FY 1980. Payload

operations in the VPF will be adversely affected if these respective modifications are not made. Without the crane modification requested for the Vertical Processing Facility, the twin and twin + spinner stage IUS vehicles will have to be handled by complicated and risky workarounds which could impact schedule and jeopardize the important Galileo mission. Life Science requirements in previous programs were not as extensive as those planned for the Space Shuttle era and were handled in temporary facilities. If this project is not provided, the extensive Life Science program planned for the Shuttle era will have to operate in temporary, inadequate facilities, resulting in the degradation of the extent and quality of the Life Sciences experiments and incur additional operating cost.

PROJECT DESCRIPTION:

Prior work (FY 1977) in the O&C Building provided for modifying the high and low bay areas by removing Apollo era equipment, and constructing and installing assembly and checkout workstands. Mechanical and electrical systems were modified and extended to new interfaces with the Spacelab workstands, and control rooms were refurbished. The O&C Building will be modified for Level IV "hands on" payload integration by providing power, grounding, fluids, gases, raised flooring and fire protection. Minor architectural modifications will be performed to provide increased laboratory and control room capabilities (Figure 2).

Modifications in the Vertical Processing Facility continue work begun with FY 1978 resources to accommodate vertical payload processing. The FY 1978 resources provided for two assembly, test, and checkout stands with vertical payload handling devices. Each workstand has a series of fixed and moveable platforms that allow access to critical areas of the many different vertical payloads to be processed through the VPF. The entrance door to the the VPF has been modified, and electrical, pneumatic, mechanical and support services have been provided to the workstands. This FY 1980 request provides a 35-ton bridge crane to replace the existing 25-ton unit in order to lift the heavy twin and twin + spinner stage IUS vehicles now planned for processing. Studies show that the existing crane rails are of sufficient size to support the 35-ton crane. The present 25-ton crane will be removed, and the larger crane will be installed and checked out between missions in CY 1981.

The third element of this project provides for the modification of the Missile Assembly Building No. 01732 (Hangar "L") at CCAFS to provide a Life Sciences Support Facility. This facility will be used for Life Sciences payload operations, including specimen receipt, holding, conditioning, and experimentation, and payload integration preparation. It will also provide Principal Investigator support with offices, labs, and equipment. This project will provide resources for modifying the interior of Hangar "L" (as shown in Figures 3, 4 and 5) by rearranging walls, partitions, and ceilings. Those areas to be modified as animal holding rooms will be provided with non-porous washable surfaces. Other existing areas will be modified into laboratories, experiment areas, offices, and a conference room. The mechanical systems that support these areas must also be modified

to support the new arrangement of functions. The heating, ventilating and air-conditioning systems are to be rehabilitated and modified to provide closely controlled environments in the various specialized areas. The interior water distribution and compressed air systems must also be modified. An emergency power system consisting of a 480-volt generator and switch gear will be installed. The electrical distribution system is to be modified to also serve the new functional areas of the buildings. Upgraded lighting is required in critical locations and will be provided by the use of energy-efficient fluorescent fixtures. Local switches and timers will also be provided to optimize energy use. Facility equipment such as laboratory benches, environmental chambers, an incinerator, cage washer, and autoclaves will be provided and installed as part of this project.

43-843 O - 79 - 46

PROJECT COST ESTIMATE:

The bases of this cost estimate are Preliminary Engineering Reports.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	2,610,000
Modify O&C building	---	---	---	390,000
Architectural/structural	LS	---	---	(130,000)
Mechanical systems	LS	---	---	(260,000)
Modify vertical processing facility	---	---	---	610,000
35-Ton Bridge Crane (VPF)	LS	EA	---	(610,000)
Modify Hangar "L"	LS	---	---	1,610,000
Architectural/structural	LS	---	---	(473,000)
Mechanical systems	LS	---	---	(312,000)
Electrical systems	LS	---	---	(435,000)
Life science support equipment	LS	---	---	(390,000)
Fallout Shelter (not feasible)	---	---	---	---
Total				2,610,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Pictorial of O&C
Figure 3 - Ground Floor Plan, Life Science Support Facility (LSSF)
Figure 4 - Second Floor Plan (LSSF)
Figure 5 - Elevation and Cross Section (LSSF)

OTHER EQUIPMENT SUMMARY:

Centain non-collateral equipment to be funded from R&D resources, and estimated to cost $3-4 million, will be required to support initial operations.

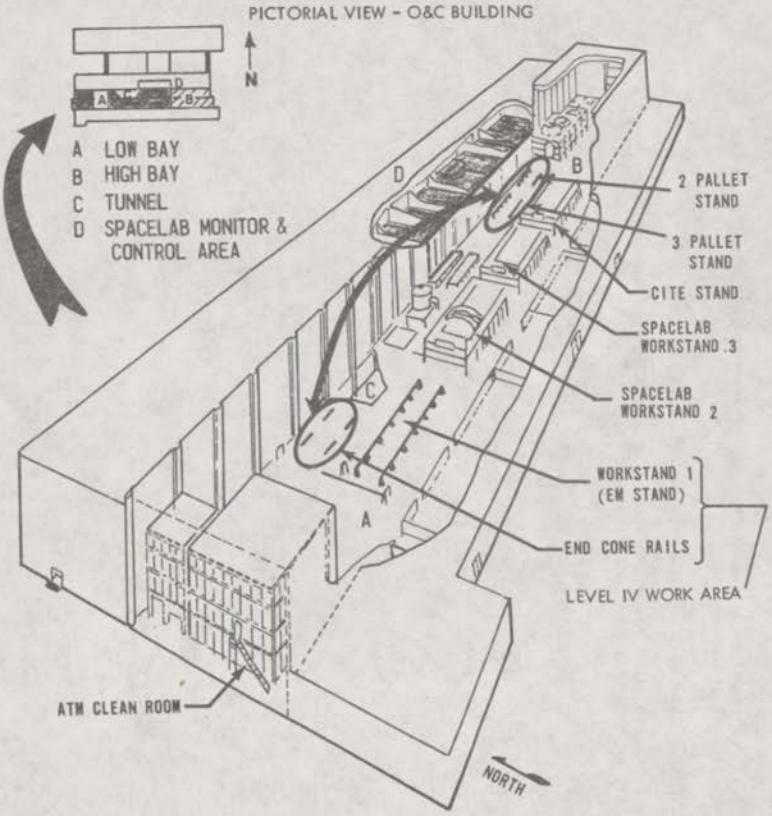
FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

Additional funding for basic plant and equipment is not anticipated. However, future modification work may be necessary to satisfy unique future programmatic needs.

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1980 ESTIMATES
REHABILITATION AND MODIFICATION FOR PAYLOAD GROUND SUPPORT OPERATIONS

CF 11-9

PICTORIAL VIEW - O&C BUILDING



JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1980 ESTIMATES
REHABILITATION AND MODIFICATION FOR PAYLOAD GROUND SUPPORT OPERATIONS

GROUND FLOOR PLAN

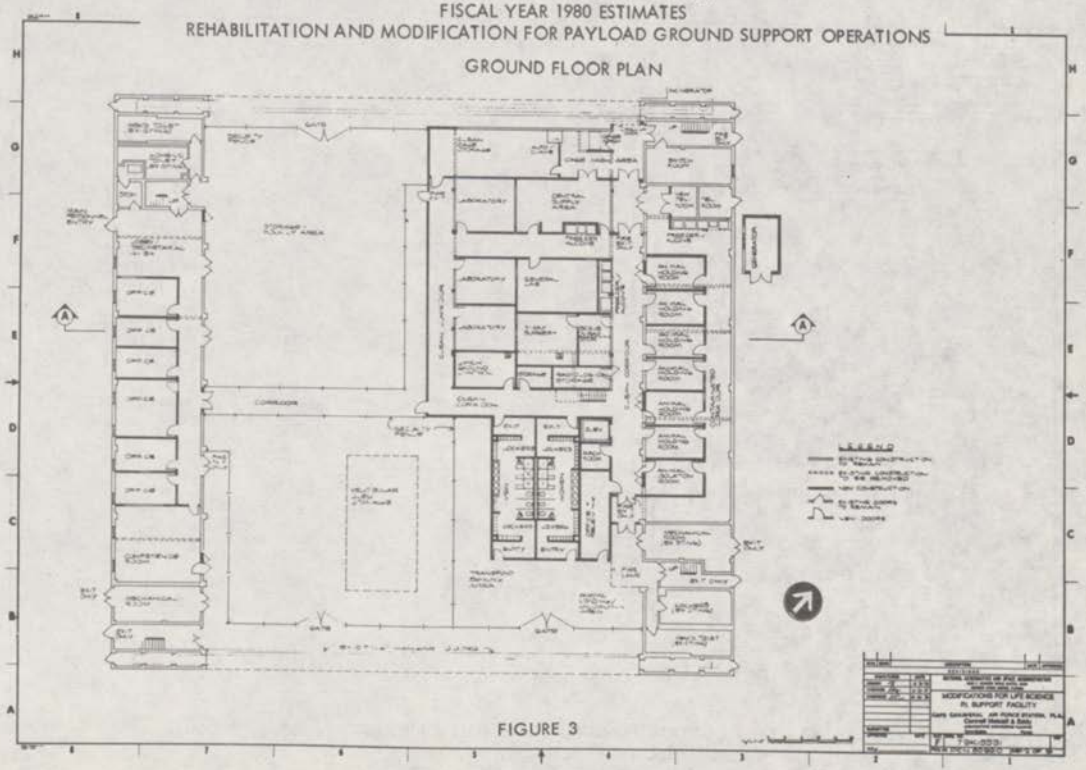


FIGURE 3

CF 11-10

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1980 ESTIMATES
REHABILITATION AND MODIFICATION FOR PAYLOAD GROUND SUPPORT OPERATIONS

SECOND FLOOR PLAN

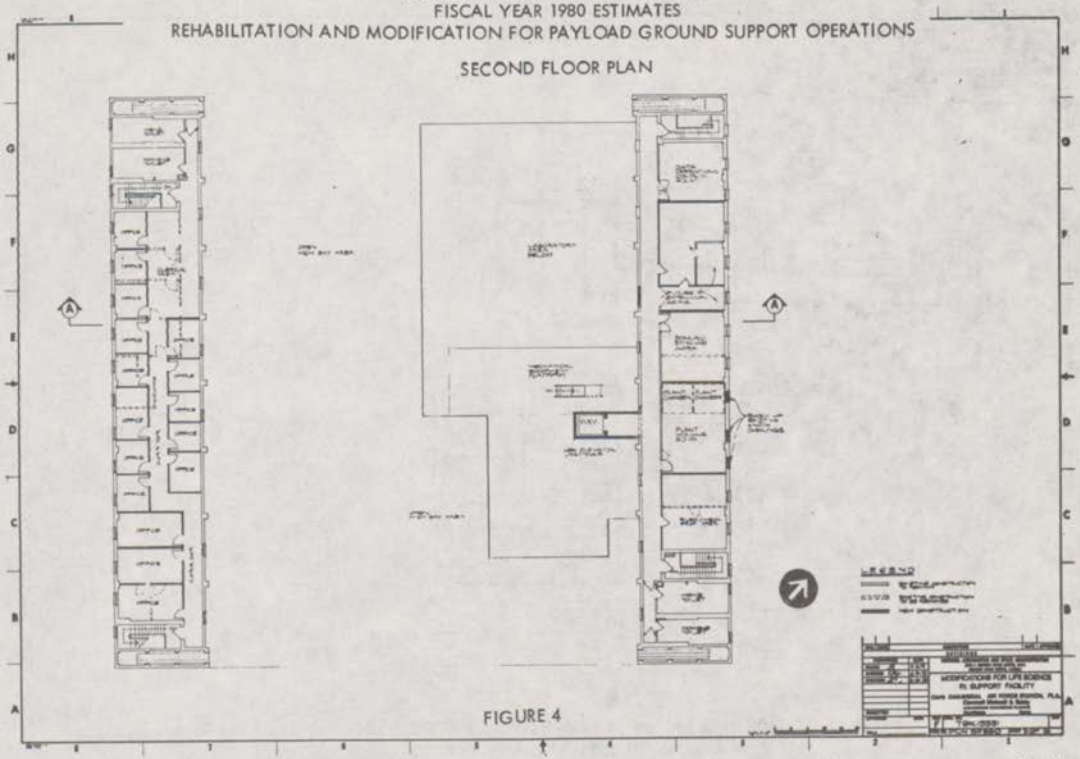


FIGURE 4

CF 11-11

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1980 ESTIMATES
REHABILITATION AND MODIFICATION FOR PAYLOAD GROUND SUPPORT OPERATIONS

ELEVATION AND CROSS SECTION

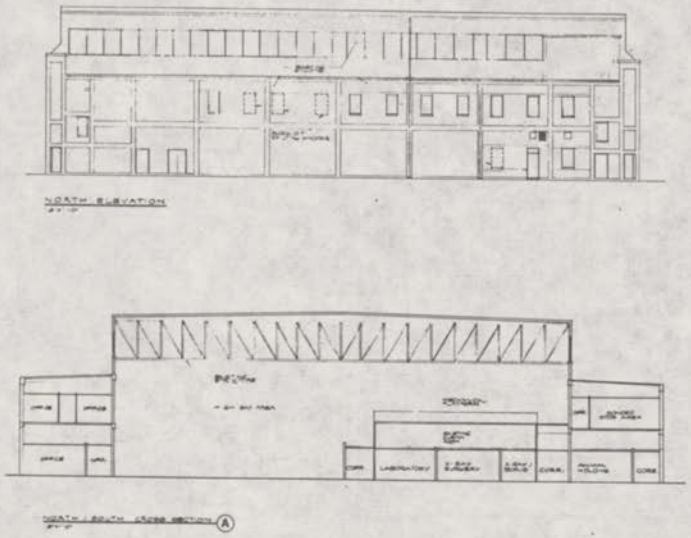


FIGURE 5

CF 11-12

AMES RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

MODIFICATION OF AND ADDITION TO MATERIALS SCIENCES LABORATORY (N-240)

LOCATION PLAN

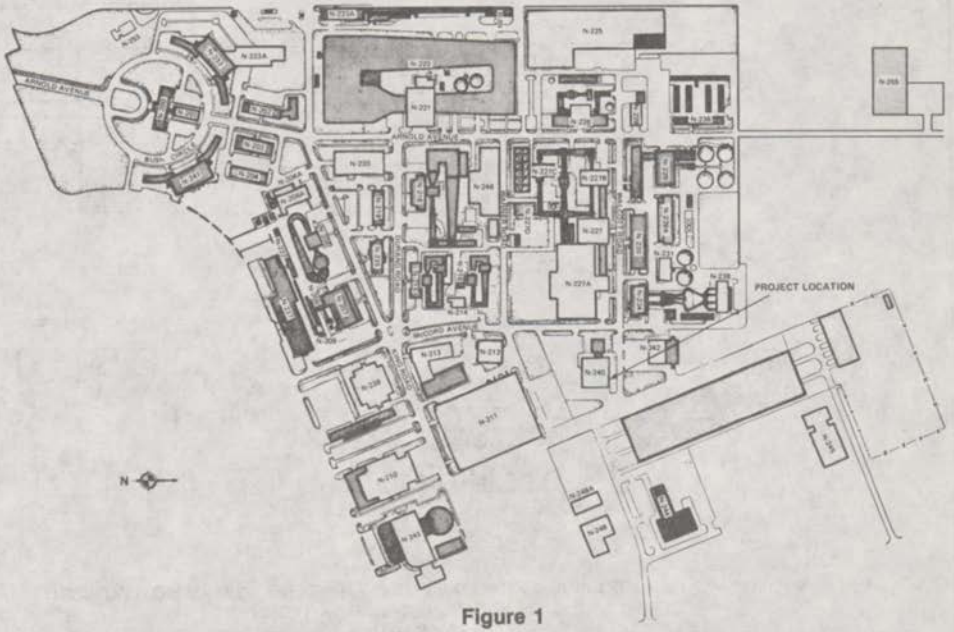


Figure 1

CF 11-13

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE:	Modification of and Addition to Materials Sciences Laboratory (N-240)
INSTALLATION:	Ames Research Center
FY 1980 CoF ESTIMATE:	$1,640,000

LOCATION OF PROJECT: Moffett Field, Santa Clara County, California

COGNIZANT HEADQUARTERS OFFICE: Office of Space Science

FY 1979 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	130,000	---	130,000
Capitalized investment	N/A	2,188,946	2,188,946
Total	130,000	2,188,946	2,318,946

SUMMARY PURPOSE AND SCOPE:

This project provides for the construction of a 11,600 gross square foot (1,077 square meter) two-story addition to the east side of the Materials Sciences Laboratory, Building N-240, and modification of 16,000 gross square feet (1,486 square meters) of existing high bay and laboratory (Figure 1). The combined space will be used to support the Life Sciences Flight Experiments and Vestibular Function Research Programs. The facility will house research equipment and personnel in support of the development of animal, plant and tissue experiments for the Spacelab Life Sciences program. The building will contain laboratories equipped for research and flight experiment development. Specific programs to be supported are biological and plant

physiology, biochemistry, microbiology, and radiobiology. Associated personnel and general laboratory space will be provided for spaceflight related Life Sciences activities.

PROJECT JUSTIFICATION:

NASA planning for the execution of Spacelab experimentation, envisions a multi-Center involvement in the development and integration of human, plant and animal experiments. Ames Research Center (ARC) has been assigned the lead role in the development of the plant and animal experiments for Spacelab. The first dedicated Life Sciences laboratory is scheduled to be launched in late 1981 and involves at least 15-30 biological investigations. The responsibility assigned to ARC for the Life Sciences Spacelab missions requires that a unique facility be developed at the Center to accommodate the activities required to fulfill its role over the coming years. These activities include:

- Receipt, inspection, checkout and utilization of ground support equipment (GSE) and flight equipment.
- Receipt and maintenance of biological specimens and transportation to other life sciences centers.
- Development and checkout of spaceflight hardware and software.
- Definition of the data requirements for experiments and implementation of a data management plan.
- Preliminary training of principal investigators (P.I.'s), payload specialists and mission specialists in experimental operation procedures.
- Technical assistance to P.I.'s in preparing biological specimens for preflight, flight and post-flight tests and analyses.
- Packaging and shipping developed and checked out experiments to other NASA Centers for final stages of integration.
- Flight support for testing of experimental controls.
- Post-flight support for control experiments, data reduction and reporting.

The activities performed in this facility require a close interaction among ARC's management staff, engineers, support contractors, P.I.'s, and related groups at other NASA Centers. This will involve 45-48 people rotating through the facility. The new facility must provide accommodations for the personnel involved in the coordination and management of experiments as well as those directly involved in the experiments.

Participation in the first dedicated Life Sciences laboratory requires additional office space, and a physical area in which to carry out the development and management activities. Technical space is required in the facility for flight experiment build-up, test and check-out areas, as well as supporting laboratory, control room, live specimen processing, and office areas. General laboratory space is required for spaceflight related Life Sciences activities such as:

- Development and testing of biological life support hardware and new methods of feeding, watering, waste removal, and air revitalization.

- Development of advanced animal bioinstrumentation and telemetry systems.

- Determination of the tolerance of biological systems to the various environmental parameters of spaceflight (e.g., noise, vibration, confinement, etc.).

IMPACT OF DELAY:

This facility is required to meet the launch date of the first dedicated Life Sciences Spacelab mission, SL5, scheduled for 1981. Construction in FY 1980 is necessary for construction, equipment installation, personnel training and systems check-out before the facility is operational. An additional one year lead time, prior to launch, is also required for the preparation of the experiments for Spacelab. This project is directly tied to the first dedicated Life Sciences launch and delay would jeopardize the program. This facility, as configured, will support future Life Sciences programs on Spacelab at a maximum of one dedicated launch per year. Consequently, future missions are contingent upon this facility project.

PROJECT DESCRIPTION:

This project consists of a new two-story addition to the east side of Building N-240, and complete modification of functions in the east half of Building N-240 (Figure 2). The new addition will be 11,600 gross square feet (1,077 square meters) with a steel frame structure and precast concrete "tilt-up" exterior walls treated to match the existing building.

The first floor of the addition will house the live specimen area and will include a delivery dock, holding rooms, minor surgical area, and general utility space. Floors, walls and ceilings in these areas will be nonporous surfaces with a washable finish. The balance of the first floor will contain offices, laboratories related to the high bay area, locker rooms, and toilet facilities. A hydraulic elevator will be included to carry equipment supplies to the second floor. A new entrance will be provided to accommodate personnel and visitors associated with the facility. Three stairways, one of which will lead to the roof, will be provided to accommodate internal circulation and to comply with Life Safety Code requirements. The second floor will include office space, conference room, and toilet facilities.

The modification of 16,000 square feet (1,486 square meters) of high bay and laboratory area in Building N-240 will provide space for experiment development, integration, check, laboratory functions, storage, shipping, and receiving. The accelerator vault will be modified for an electronic laboratory, shop and bonded stores. A new corridor through the existing testing area west of the high bay will afford circulation among areas not related to this project. A portion of the mechanical room will be modified for a test control computer room with a raised floor system.

PROJECT COST ESTIMATE:

The cost estimate for this project is based on a completed Preliminary Engineering Report.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	1,640,000
Addition to Building N-240	---	---	---	1,240,000
Site preparation	LS	---	---	(190,000)
Architectural	SF	11,600	25.45	(295,000)
Structural	SF	11,600	32.75	(380,000)
Mechanical	SF	11,600	25.85	(300,000)
Electrical	SF	11,600	6.45	(75,000)
Modification to Building N-240	---	---	---	400,000
Architectural	SF	16,000	8.10	(130,000)
Structural	SF	16,000	2.20	(35,000)
Mechanical	SF	16,000	5.60	(90,000)
Electrical	SF	16,000	9.05	(145,000)
Fallout Shelter (not feasible)	---	---	---	---
Total				1,640,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Site Plan

OTHER EQUIPMENT SUMMARY:

Associated with this project is approximately $1.8 million of research and development equipment. This is needed to make this facility complete.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

There are no presently known future requirements to complete this project.

AMES RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

MODIFICATION OF AND ADDITION TO MATERIAL SCIENCES LABORATORY (N-240)

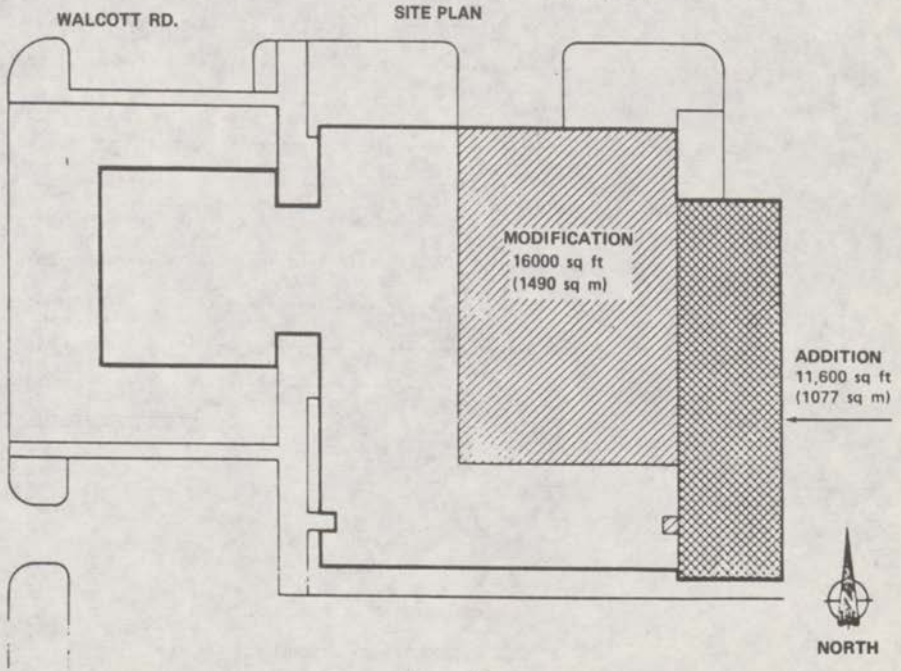


Figure 2

CF 11-20

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

SUMMARY

REPAIR

	Amount (In dollars)	Page No.
Summary of Project Amounts by Location:		
Ames Research Center	1,280,000	CF 12-4
Goddard Space Flight Center	595,000	CF 12-5
Jet Propulsion Laboratory	850,000	CF 12-6
Johnson Space Center	910,000	CF 12-8
Kennedy Space Center	185,000	CF 12-10
Langley Research Center	1,470,000	CF 12-10
Lewis Research Center	830,000	CF 12-11
Marshall Space Flight Center	1,305,000	CF 12-13
Michoud Assembly Facility	990,000	CF 12-15
National Space Technology Laboratories	1,035,000	CF 12-16
Wallops Flight Center	1,200,000	CF 12-17
Miscellaneous Projects less than $150,000 each	1,350,000	CF 12-19
Total	12,000,000	

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CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE:	Repair of Facilities not in Excess of $500,000 Per Project
INSTALLATION:	Various Locations
	FY 1980 CoF ESTIMATE: $12,000,000
FY 1978: None	FY 1979: None

COGNIZANT INSTALLATIONS/LOCATION OF PROJECT: Various Locations

COGNIZANT HEADQUARTERS OFFICE: Office of the Comptroller

SUMMARY PURPOSE AND SCOPE:

This is a new project for inclusion in the Construction of Facilities (CoF) program.

This program is to provide for the larger, more basic and essential repairs to facilities at NASA field installations and Government-owned industrial plants engaged in NASA activities. Included in this project are those priority repair facility needs for FY 1980 that can be foreseen at the time of the submission of these estimates, and that are estimated not to exceed $500,000 per project. The thrust of this program is to provide a means to restore appropriate facilities or components thereof, including collateral equipment, to a condition substantially equivalent to their originally intended and designed capability. It includes the substantially equivalent replacement of utility systems and collateral equipment necessitated by incipient or actual breakdown and consideration of associated obsolesence. The extent and nature of this work also includes major preventive measures which are normally accomplished on a cyclic schedule of greater than one year. Each of the individual items contained in this year's request for facility repair work is in itself a proper facility project. Each represents the consistent application of the approved and accepted definition of a facility project and, in this context, each includes all of the facility work that needs to be done in the budget time frame, or all

of the facility work that can be done in that time frame, as limited by constraints other than availability of resources. Each individual item has been evaluated against applicable need dates, time lines and the sbility to place the planned work under contract in the budget time frame.

The $12,000,000 request for FY 1980 is for those projects that are required in direct support of critical programmatic and institutional requirements.

PROJECT JUSTIFICATION:

In prior years it had been the objective to accommodate the larger repair projects within the Rehabilitation and Modification project line. This had been done by an administrative determination that required repair projects in excess of $100,000 to be managed as Rehabilitation and Modification projects. This had been working reasonably well until the past year or two when there appeared to be a surge of repair work. Examination of this indicated that this surge was directly related to the fact that a major portion of our building inventory is in the 15 + year old bracket and increases in repair requirements were to be normally expected. In fact, there are statistical bases to this evaluation that prove that maintenance and repair costs for mechanical and electrical systems in a typical building are almost three times higher during the 16-to 30-year period of a building's life than they are during the initial 15 years of beneficial occupancy. At about the 15-year point many electrical and mechanical components reach the end of their serviceable or economic life and should be replaced in the interest of long-term economy. Continued repair of these components usually requires more resources in the long run than replacement after the end of the economic life of the original components. This condition is now being realized at locations such as Goddard Space Flight Center (GSFC) and Johnson Space Center (JSC). These more specific points, when coupled with the sheer age of other portions of the plant, such as at Langley Research Center (LaRC) and Lewis Research Center (LeRC), demand a more positive approach to the needs of repairs which are urgent and vital. Some 75 percent of our physical plant is in the 16- to 30-year old bracket.

As a consequence, a new budget line item is included in this year's CoF budget estimates. This program will achieve many objectives:

a. Provide the matter of repair an appropriate and badly needed better focus.

b. Permit central management and oversight, and thus better address priorities and changing conditions.

c. Allow R&PM facility services budget estimates to address timely recurrent annual costs and avoid periodic peaks for large cyclic preventive work.

This is all within the major thrust of preservation of the existing physical plant which, at its $6.0 billion initial cost, represents approximately $13.5 to 14.0 billion in 1979 dollars. It is recognized that, as such, repair is closely related to rehabilitation/modification. However, it is intended that the major distinction between these classes of work be whether or not the intended work is to bring the "facility and its components to a condition substantially equivalent to its designed capacity, efficiency and capabilities." If such is the case, the work is properly classed as "repair."

An analysis of each of the projects which follows indicates that this is the type of work which, in a prudent business-like way, must be addressed and progressively accomplished. Unless this is done, resultant risks are increased, and future costs of the specific work will be greater. More importantly, there will be increased "unscheduled breakdowns", impacting missions, and costly situations of "Emergency Patch and Repair" which will be required to make our facilities as useful as possible.

This project includes only facility repair work having an estimated cost not in excess of $500,000. The work covered in this project is of such a nature and magnitude that it cannot be accomplished by routine day-to-day facility maintenance and repair activities, or by related routine facility work efforts that are provided for in other than CoF estimates. Each repair project estimated to cost more than $500,000 is reflected as a separate major CoF line item project. Not included in this project are the other minor facility projects; Rehabilitation and Modification, and Minor Construction facilities projects required in FY 1980. Provisions for of these requirements are made under separate projects which are also included in these CoF estimates.

PROJECT DESCRIPTION:

Proposed repair items for FY 1980 are outlined under "PROJECT COST ESTIMATE"; they total $12,000,000. Deferral of this work would create high risks and consequences. These would impact program schedules and critical institutional facilities requirements in support of Agency mission goals and objectives.

Of the total projects listed, $10,650,000 represents discrete work packages at designated NASA installations. The remaining $1,350,000 relates to those smaller repair projects estimated to cost $150,000 or less, the nature and purpose of which are the same as for that work specifically delineated but which, because of their individual smaller sizes, are not listed by item. At this time, the items in this total package are considered to be of higher priority. They have been carefully selected from lists totalling about $25 million. This FY 1980 listing thus represents a modest increment in relation to the existing total backlog of this type of work for which provisions must be made over the next several years.

As indicated above, the projects in this request are considered to be of the highest present priority on the basis of relative urgency and expected return on the investment involved. It is recognized, however, that

during the course of the year some rearrangement of priorities may be necessary. It is also realistic to assume that a change in some of the items to be accomplished within the allocated resources may be required. For the purpose of justifying this estimated facilities repair requirement, a tentative listing of projects is set forth under "PROJECT COST ESTIMATE." They will be accomplished on a priority basis. The total of $10,650,000 for separate projects relates to the following broad categories of facilities:

a. Utility Distribution Systems	3,015,000
b. Buildings and Structures	4,435,000
c. Roads and Grounds	1,165,000
d. Equipment	2,035,000

The additional lump sum estimate of $1,350,000 for smaller projects thus provides a total of $12,000,000 for this program.

PROJECT COST ESTIMATE:

A. Ames Research Center (ARC)	1,280,000
1. Repair of Variable Frequency Power Systems	440,000

This project provides for the replacement of obsolete switchgear, circuit breakers, controls, central equipment of four motor generator sets, and the two associated 6.9 kv feeders which make up the ARC variable frequency power system. This equipment has been in continuous operation without a shutdown for major repairs since its installation in 1945. Most of the equipment is no longer manufactured and equipment which is manufactured has become more difficult to acquire. Numerous delays in the operation of the tunnel have occurred because of problems with deformed shafts, link pins and electrical contacts. This facility had four failures in a six-month time span (January-June 1978) impacting the operation of the major facilities that utilize this power. Failure to replace this equipment will result in more unscheduled shutdowns. This system supports work performed in the 2x2-Foot Wind Tunnel, Building N-227; 20g Centrifuge Building, Building N-221A; and the 40x80-Foot Wind Tunnel, Building N-221.

2. Repair of Electrical Drive Equipment..... 310,000

This project provides for the overhaul and rewinding of the motors and generators associated with the 7x10-Foot Wind Tunnel, Building N-216, drive system. This work includes the replacement of obsolete switchgear, circuit breakers, controls, and the overhaul of auxiliary support motors and generators located in the Thermal Protection Laboratory, Building N-234, and the Arc Jet Facility, Building N-238. Most of the equipment has been in operation for 30 years without major maintenance or overhaul. Many of the parts are not available for the switchgear and circuit breakers. As a result of the unavailability of the equipment, many parts are specially fabricated thus costing more than new parts. This equipment has become unreliable with a high risk of failure. In the event of failure, the operation of associated facilities (3.5-Foot Wind Tunnel and Air Jet Facility) also will be severely affected.

3. Repair of Building Exteriors, Various Buildings..... 165,000

This project provides for the repair of the siding to Buildings N-206, N-206A, N-207, N-211, N-229, N-230, N-231, N-234, N-235, and N-236. This involves waterproofing concrete surfaces of the buildings and sandblasting and painting of two metal buildings. In addition, the windows and screen replacements will be recaulked. These buildings are an average of 22 years old and in need of repair. During heavy rains, the concrete buildings leak causing water damage to the interior of the buildings. Rust and corrosion have seriously deteriorated the exterior surfaces of the metal buildings.

4. Repair of the Steam Vacuum System, Building N-234A..... 365,000

This project provides for the repair of the internal surfaces of the Steam Vacuum System. This work will include the cleaning, rebuilding and epoxy coating of the piping and replacement of the turning vanes and nozzle assemblies. In addition the existing cooling water tank has a moveable wooden baffle which is damaged and does not effectively separate the cold and hot water. The wooden baffle will be replaced with new diffuser type piping. The repair of this system will reduce the steam losses due to leaks and increase the efficiency of the system. If this deterioration is allowed to continue, the facility could be damaged beyond economic repair.

B. Goddard Space Flight Center (GSFC)..... 595,000

1. Repair of Elevators, Buildings 14 and 23..... 200,000

This project provides for the repair of two hydraulic elevators, one in the Spacecraft Operations Facility, Building 14, and the second in the Data Interpretation Laboratory, Building 23. This repair work

includes the cabs, related equipment, and all worn parts. The elevator in Building 14 was installed when the building was constructed in 1964, and the one in Building 23 during construction in 1965. These elevators have been in constant use since then for transporting both personnel and heavy equipment in support of spacecraft programs and data reduction. The downtime of these elevators is now excessive due to their age and the difficulty in obtaining parts for the outdated equipment. This equipment must be repaired at this time to increase the reliability to an acceptable level required by the programmatic computer and data reduction operations being conducted in these buildings. The delay in providing for this repair will result in the continuation of the present unsatisfactory conditions, increased downtime and maintenance cost, more expensive cost in the future, and inadequate support of operational spacecraft programs.

2. Repair of Roofs, Instrument Construction and Installation Laboratory, Building 5, Business Operations Building, Building 18, and Meteorological Systems Development Laboratory, Building 21..... 395,000

This project involves the repair of approximately 145,000 square feet (13,470 square meters) of roof surfaces of Buildings 5, 18, and 21 at GSFC. This work includes the removal of the deteriorated roofing material and insulation, and the installation of new material. This work also includes the repair of the flashing, exterior siding, masonry work, and the roof drainage where necessary. A moisture invasion and leak locating survey was conducted of 750,000 square feet (69,675 square meters) of built up roofing serving the GSFC facilities. This survey revealed chronic cracking of roofing felts, severe edge and drain flashing failure, and blisters on the roofing of these buildings. These roofs have further deteriorated since the survey and now require extensive repair work to restore them to acceptable conditions. Roof deterioration due to normal aging and necessary roof traffic has resulted in an increasing frequency of roof leaks. This condition has resulted in extensive maintenance costs and threatens scientific and building equipment and related programmatic test operations being conducted in these buildings. For these reasons, Buildings 5, 18, and 21 were selected as the most urgent need for roof repair. The remaining buildings surveyed have been repaired or are in a more favorable condition and major roofing repairs can be deferred.

C. Jet Propulsion Laboratory (JPL)..... 850,000

1. Repair to Exteriors of Various Buildings..... 400,000

This project provides for the repair, protection and exterior sealing of four buildings. The work involves the exterior painting of approximately 130,300 square feet (12,100 square meters) of surface. The areas include the Space Science Instrument Systems Laboratory, Building 168, at 36,600 square feet (3,400 square meters); the Engineering Office Building 169 at 33,700 square feet (3,100 square meters); the Physical Science Laboratory Building 183, at 40,500 square feet (3,800 square meters); and the Procurement Office

Building 190, at 19,500 square feet (1,800 square meters). Also included is the caulking of 55,700 linear feet (17,000 meters) of curtain wall joints in all four buildings and the epoxy pressure grouting of 4,400 linear feet (1,300 meters) of cracks in the concrete structure of Building 168 at 2,100 linear feet (600 meters), and Building 169 at 2,300 linear feet (700 meters). This work, which supplements the roof repairs done several years ago, will complete the sealing and waterproofing of the exterior surfaces of these four major structures at JPL. The exterior painting and sealing of the minor structure cracks of these buildings has not been done since the 1967-1969 period. The present paint is long overdue for recoating, repairing and applicable procedures to bring it up to a quality surface. In particular, attention must be paid to the curtain wall construction of these buildings which, over the years, tends to deteriorate and, with dried out caulking, induces cracks that permit the entrance of rain water at numerous locations. This, in turn, accelerated rusting and structural and wall/column deterioration. This work is basic to the long term preservation of these facilities.

2. Repair to Roofs on Various Buildings..... 220,000

This project provides for the repair, replacement and modification to the roofs of four buildings. Replacement of roofing is proposed for 12,400 square feet (1,200 square meters) of the 25-foot Space Simulator, Building 150; 4,100 square feet (400 square meters) for the west portion of the Engineering/Mechanics Building 157; and 3,400 square feet (300 square meters) of the penthouse area of the Telecommunications Building 238. Some 10,200 square feet (900 square meters) of the Materials Research Processing Laboratory, Building 158, will have a new roof installed along with demolition of abandoned cooling towers thereon, replacement of parapet caps and resloping of the roof for proper drainage and raising of the air handler equipment thereon. The roofs of these four buildings, in the areas specified, are in extremely poor condition. The recent winter rainstorms caused numerous leaks that penetrated the interior of the buildings to the extent that water had to be mopped up in Building 158. Also, leakage was evident in the other buildings. This specific work is essential now and of sufficient urgency that it must be included in this request at this time. It is felt that further deterioration of the roofs would provide an untenable situation for the tenants on the upper floors of these buildings and compound the deterioration of these facilities.

3. Repair of Roads, Table Mountain, California..... 230,000

This project provides for the repair of approximately 140,000 square feet (13,000 square meters) of badly damaged roads and the rerouting of approximately 7,000 square feet (650 square meters) of existing road at Table Mountain, California. The Table Mountain Facility is a government-owned site which is used to support JPL programs through astronomical observations/research, and for the development and testing of solar power devices for spacecraft applications. The roads within the main complex all require the removal of existing paving, removal of all wet base material and replacing it with suitable material, compaction of new base, and

the installation of a new 3-inch (7.6-centimeters) asphaltic concrete surface with a seal coat. The road to the Users' Area will need a slurry coat on existing surface only. A portion of the existing boundary road will be rerouted through the complex. A recent inspection of the road conditions at Table Mountain disclosed that, in all cases, the roads showed excessive cracking and breaking due to unstable base material. These roads require this repair in order to place them in a more safe and satisfactory condition. The area of Table Mountain is subjected to extremes in climate from very hot to very cold and from very wet to very dry, and general maintenance would not be adequate to repair them to an acceptable condition.

D. Johnson Space Center (JSC)..... 910,000

1. Repair of Steam, Chilled Water, and Compressed Air Systems, Building 24 Complex..... 200,000

This project addresses a long-range requirement for the repair of various components of JSC's primary utilities generation and transmission systems located in the Central Heating and Cooling Plant, Building 24, and associated utility tunnels and cooling towers. The work includes repair of three central utility air compressors, heat exchangers, controls, a water pump, and cooling water piping in the compressed air generation system of Building 24. The work also includes replacement of approximately 10 expansion joints with loops, repair or replacement of 10 valves, and repair of pipe insulation in the steam and condensate lines located in the utility tunnel system. Work on the chilled water system includes repair or replacement of 10 chilled water and condenser water valves in the utility tunnel system, and replacement of insulation on one chiller evaporator and economizer located in Building 24. The project also includes repair of four 200-horsepower condenser water pumps located at the cooling tower. Though there have been no breakdowns or outward signs of trouble, this is the time when these components have reached their normal life expectancy based on experience and manufacturers' recommendations. This work is beyond the scope and capability of the annual maintenance program. The purpose of this project is to maintain the reliability, efficiency, and safety requirements of the installation's basic utility systems that are generated and distributed from the Central Heating and Cooling Plant. These systems are essential ingredients of the Center's energy conservation program and must be maintained in optimum operating condition.

2. Repair of Roofs, Various Buildings..... 250,000

This project addresses a long-range requirement to progressively repair the roofs of buildings at the Johnson Space Center. This project provides for roof work on Buildings 9, 351, 352, 353, 354 and 380. The work will consist of removing and replacing roofing material, resealing and caulking perimeter flashing and flashing at roof penetrations, and replacement of roof insulation board as required. Moisture relief vents will be provided where excessive moisture collects. A total of approximately 46,800 square feet (4,348 square

meters) of built-up roofing and approximately 1,163 linear feet (354 meters) of neoprene flashing will be replaced on Buildings 9 (Technical Services Facility) and 380 (Hazardous Material Storage Facility). A total of approximately 19,300 square feet (1,793 square meters) of acid resistant elastomeric sheeting and approximately 1,263 linear feet (385 meters) of neoprene flashing will be replaced on Buildings 351, 352, 353 and 354, in the Thermochemical Test Area. Work on Building 380 includes the addition of a light-weight concrete fill on the roof slab and installation of a built-up roof. This project is essential to the continued operation of these JSC facilities. Over the past 12 years, the normal aging process together with various building modifications affecting the roofs and the presence of numerous roof penetrations have combined to significantly reduce the integrity of the roofs. Weathering, blistering, and flashing failures have resulted in numerous leaks and moisture penetrations. This project is needed to preclude damage to the building structures, as well as damage to interior ceiling panels, electrical panels, and sensitive equipment and electronics.

3. Repair of the Electrical Distribution System..... 230,000

This project addresses a long-range requirement to replace deteriorated feeder cables in the Center's electrical distribution system. The work includes replacing approximately 19,050 linear feet (5,806 meters) of existing 15-KV, 400 mcm, underground cable, extending from the substation to the utility tunnel, identified as feeders 1-8, 2-6, 2-7; the cable from the substation to Building 222 (feeder 3-1); and the cable from the substation to Buildings 32 and 36 identified as feeder 2-12. The existing cable in the Center's electrical distribution system has been in continuous service for the past 12 years, during which time a large amount of unscheduled maintenance has been required. Past faults have been repaired as they have occurred, but these repairs have not been of the magnitude to prevent future failures of a potentially extensive nature. The defective condition of the cable, at this stage, indicates that replacement is now required to assure the desired degree of reliability of power to the Center's facilities to avoid any major program impacts.

4. Repair of Roofs, NASA Industrial Plant, Downey, California..... 230,000

This project provides for the repair of roofs of Buildings 001 and 290 at the NASA Industrial Plant, Downey, California. The work includes the repair/replacement of 29,000 square feet (26,941 square meters) of roofing, with associated flashings and drains on Buildings 001 and 290. These buildings house important functions that support the Shuttle manufacturing program. By 1980, the roof of Building 001 will be 18 years old, and the roof on Building 290 will be 17 years old. Both roofs are in a badly deteriorated condition. The roofs on both buildings have a history of numerous leaks and have required extensive maintenance over the years. Delay in reroofing beyond 1980 could cause damage to building structure, roof insulation, ceilings, walls, and floors, as well as costly test equipment and flight-type hardware.

E. Kennedy Space Center (KSC)..... 185,000

1. Repair Roofs, Flight Crew Support Building (M7-409) and Central Supply Building (M6-744)..... 185,000

This project will provide for the repair of 85,000 square feet (7,897 square meters) of 5-ply built-up roofing, with associated base flashing, gravel stop, gutters, and downspouts on the Flight Crew Support Building and the Central Supply Building. Also included is the repair and recoating of 74,000 square feet (6875 square meters) of metal roof on the Central Supply Facility. These roofs will be 16 years old by 1980 and will require more extensive repair later if the work is not accomplished in this time frame. The roof of the Flight Crew Support Building has deteriorated to a point where it is spongy and has some blisters. Leaks occur occasionally, but the portion of the roof to be replaced has deteriorated to a point where serious leakage during inclement weather will occur more frequently. The roof of the Central Supply Building has numerous leaks which occur during both mild and heavy rainy weather. The extent of leaks and deterioration of the roof assemblies makes this repair necessary, especially since many items stored in this facility are vulnerable to water damage. "Stop-gap" measures have been taken to control the leaks, but they are only temporary measures and usually are not very effective. The only solution is the replacement of the built-up roofs and a complete rework and coating of the metal roof as this project plans.

F. Langley Research Center (LaRC)..... 1,470,000

1. Repair of Potable Water Piping, West Area..... 440,000

This project provides for the replacement of three potable water supply lines in the following locations; (1) Utility Tunnel No. 2 between Buildings 1215 and 1244; (2) along Ames Road from Building 1232 to the 10-inch (25.4 centimeter) diameter line near the Gregg Road intersection; and (3) along Durand Road then across Marvin Road past Building 1206 down to Servil Road between Buildings 1169 and 1245. A total of approximately 5,800 linear feet (1,768 meters) of 6- and 8-inch (15.2 and 20.3 centimeter) diameter water lines and associated valving will be replaced. The existing cast iron pipe lines have been in service for up to 30 years and have had numerous breaks resulting in interruption of services, as well as becoming a high maintenance item. As a consequence of the age of these pipes, there exists a significant amount of corrosion and buildup in the lines resulting in poor water with inadequate pressure.

2. Repair of the Air and Steam Lines Serving the Vicinity of Building 1154..... 390,000

This project provides for the replacement of approximately 2,000 feet (610-meters) each of the 5,000 psi (34,000,000 newtons per square meter) airline, 100 psi (689,000 newtons per square meter) airline and the

steam and condensate lines serving the vicinity of Building 1154. The lines will be installed in a shallow concrete trench having removable lids. They will be extended from Utility Trench No. 4. This work involves the replacement of valves, controls, flanges, and auxiliary equipment. The existing 5,000 psi airline was installed in 1960. Portions of the line pass through a marshy area having a saline environment resulting in corrosion of the line. As a result, there have been several failures requiring downtime that has impacted the utilization of the affected facilities. The 100 psi airline will replace a reducing station to minimize the use of the high pressure system for low pressure service. The insulated steam and condensate lines will be installed from Utility Tunnel No. 4 to the existing boiler located in Building 1154.

3. Repair of Heat Exchangers in Building 1247E..... 180,000

This project provides for the repair of two heat exchangers in the Compressor Facility, Building 1247E. The heat exchangers function with the compressors that provide high pressure air to most of the research facilities. These heat exchangers are 25 years old and have seriously deteriorated due to their age. Many repairs have been performed to plug the failing tubes. However, it is not cost effective to continue this operation because they can no longer provide adequate cooling.

4. Repair of the Instrument Research Facility, East Wing, Building 1230..... 460,000

This project provides for the repair of approximately 37,000 square feet (3,473 square meters) of laboratory and office space of the Instrument Research Facility, East Wing. The exterior repair will consist of replacing deteriorated wood window frames with insulating glass window/aluminum frame units, insulating exterior walls, and replacing exterior doors. Interior repairs to the mechanical systems to provide the required environmental control will include the conversion of the existing two-pipe induction units to a four-pipe system, utilizing modified existing central equipment. This facility was constructed in 1950 and has been modified and adapted to serve various programs for almost 30 years. This project will correct serious deficiencies that require immediate attention.

G. Lewis Research Center (LeRC)..... 830,000

1. Repair of Icing Research Tunnel, Building 11..... 380,000

This project provides for the repair of the 34-year old Icing Research Tunnel, Building 11, necessary to reduce maintenance and to eliminate the potential development of safety problems resulting from corrosion of the tunnel structure. Included is the replacement of deteriorated corner turning vanes (including the associated steam heating system) and fan inlet screen; repair of the corroded tunnel structure; replacement of obsolete electrical switchgear and drive motor auxiliary equipment controls; and repair of the tunnel

interior lighting system. The moist operating conditions of this tunnel have resulted in severe corrosion of the tunnel structure. Complete replacement of many structural components is necessary. The tunnel lighting, corner turning vanes, and fan inlet screen are similarly deteriorated. Although maintenance work has extended the useful life of this facility, major repairs are needed now to correct the present deficiencies. This tunnel, which is unique within NASA and is also the largest operating icing research tunnel in this country, supports on-going research under the Interagency and Industrial Assistance and Testing program. Typical of this research is the testing of more efficient wing heating systems; new anti-icing aircraft radio antennas, data probes, and engine components; and new pneumatic wing deicers. New areas of interest, which include icing research directed toward all-weather helicopter operation, low flying cruise missiles, and windmills for electric power generation, have increased the utilization of this facility. This repair work will restore the structural integrity and performance characteristics of this facility.

2. Repair of Roofs, Various Buildings..... 270,000

This project provides for the replacement of the roofs on Buildings 16, 66, 87, and 5 (Southwest Wing only), and a portion of the roof on Building 5 (Central Section) totaling 72,800 square feet (6,760 square meters). These roofs will be completely removed down to the support structures and new roofing systems will be installed. The new roofs will have thermal insulation as required to meet the current energy conservation standards and, where necessary, will be treated to withstand heavy traffic. Railings will be provided where necessary to meet Occupational Safety and Health Administration (OSHA) standards. Roof penetrations will be either eliminated or revised to meet current LeRC penetration standards. The roofs of these buildings, as included in this project, are from 23 to 36 years old. Separated flashing, roof surface blisters and punctures, and damage due to traffic have resulted in water saturated insulation. This condition increases heat losses while contributing to further roof degradation. Although routine repair and periodic maintenance of the roofs on these research facilities has been accomplished, these roofs have deteriorated to the point where complete replacement is necessary. In addition, this project provides for necessary localized repairs on over 500,000 square feet (46,450 square meters) of roofs that have been recently replaced. This work will also result in an estimated annual energy savings of 2.6 billion BTU per year or about $10,000 per year.

3. Repair of Exterior Surfaces, Various Buildings and Piping Systems..... 180,000

This project provides for the exterior surface repair of the 10-Foot x 10-Foot (3-Meter x 3-Meter) Supersonic Wind Tunnel (SWT) Loop, Building 85 (tunnel and building portions); the 10-Foot x 10-Foot SWT Secondary Compressor and Drive Building, Building 87; the 10-Foot X 10-Foot SWT Main Compressor and Drive Building, Building 90; the 10-Foot X 10-Foot SWT Exhauster Building, Building 114; and all major Central Air System combustion air and altitude exhaust piping. Included is the surface preparation and coating of corroded exterior metal surfaces. Surface repair of exterior iron, steel, and other metals at LeRC is required on

approximately 7-year intervals to avoid serious corrosion of structures and piping and to preserve the aesthetic value of the Center. Many of the facilities at LeRC consist essentially of exterior metal surfaces. This is particularly true of the 10-Foot x 10-Foot SWT and the Central Air System piping. The massive tunnel sections and the network of large and small diameter air piping routed throughout the Center are plainly visible and, like all exterior surfaces at LeRC, are subjected to the extreme weather conditions and corrosive industrial atmosphere of the Cleveland, Ohio area. Some of the surfaces included in this project are already showing signs of deterioration such as thin finish coats; exposed or peeling undercoats; rusted joints, seams, and brackets; and rust-streaked surfaces. To preserve the Government's investment in facilities, LeRC has established a 7-year cycle for these necessary repairs. These facilities will reach the end of their 7-year interval in FY 1980.

H. Marshall Space Flight Center (MSFC)..... 1,305,000

1. Repair High Pressure Gas System..... 450,000

This project involves the repair and refurbishment of the 5,000 psi gaseous nitrogen and 3,500 psi "flight grade" air systems in twelve buildings throughout the Center. Included will be localized repair, refurbishment or replacement of the high pressure control systems, pumps, storage vessels, components, distribution piping, regulators, and valves. There is one high pressure gaseous nitrogen pumping station, two "flight grade" air pumping stations, 95,000 linear feet (28,956 meters) of primary distribution system and thirty high pressure reducing stations in these systems. This entire complex services the Marshall Center test stands, shops, laboratories and support facilities. The system will be recertified from other resources to permit full operational use upon completion of this project. These systems were installed in the 1950's and have deteriorated through age and heavy cyclic use. They are now at the end of their 20-year design life. Radiographic inspections of the systems have revealed deterioration in welds, and portions of the systems have been down rated and can only be operated at reduced pressures. Deterioration of these systems seriously affects the reliability required to support research and development associated with on-going and future programs. The nitrogen and air systems continually lose pressure through various leaks. Failures and serious defects in the systems are being found and corrected at an increasing rate by "breakdown" maintenance. This, coupled with the known age and validated "real life" condition, confirms the need for this planned repair work by not later than the FY 1980 time frame.

2. Repair High Pressure Water System Valves..... 200,000

This project provides for the repair of large valves in the high pressure water system servicing the MSFC test areas. Included are: seven 16-inch (40.6 centimeter) manual gate valves located in the fire protection system in the east test area; one manual and eight electrically operated 30-inch gate valves and

nine 8-inch (20.3 centimeter) bypass valves located on the 30-inch (76.2 centimeter) main feeding the test facility in the east area; and three 20-inch (50.3 centimeter) gate valves located at Building 4572 (Propulsion and Structural Test Facility). Fire protection in the test area is hampered by deteriorating valves and lines, particularly in the east test area. Most of the test area high pressure water system was installed in the late 1950's without proper cathodic protection. As a result, the valves have deteriorated, are now leaking badly and must be repaired in the near future, as fire protection must be provided continuously to protect costly government equipment and facilities. Repair of the 30-inch valves is required to maintain cooling capability essential to fulfilling minimum test capability projected in the 1980 time frame.

3. Repair Air-Conditioning Components..... 300,000

This project will repair major air-conditioning system cooling towers and chillers by replacement with substantially equivalent units. Four cooling towers, with a total capacity of 875 tons, are to be replaced. In addition, two water-cooled chillers with a total capacity of 425 tons are to be replaced. Also included will be miscellaneous piping, valves, and electrical work necessary to complete the work. This equipment ranges in age from 15 to 30 years but had an original design life of only 10 years. The equipment is in a very deteriorated condition and requires continual heavy maintenance to keep it operable. It is more economical to replace the components than to continue the "patchwork" repairs. All of the facilities supported by these components are in direct support of the Space Shuttle and Spacelab programs and various other research and development efforts essential to future programs. This repair work is essential in the FY 1980 time frame.

4. Exterior Repairs, Various Buildings..... 355,000

This project provides for the repairs to and painting of approximately 460,000 square feet (42,734 square meters) of exterior walls, doors, windows and other surfaces of Buildings 4476 (Environmental Test Facility), 4550 (Structural Test Facility), 4707 (Shop and Assembly Building), and 4760 (Surface Treatment Facility). Work includes surface preparation, minor repairs, caulking and application of 2 coats of paint. Protective painting guards against the cumulative damaging effects of wear, deterioration and weather, and preserves the facility's capability for prolonged operation. The exterior surfaces are peeling, moisture is getting into the wood and other surfaces, and the caulking has deteriorated to a point where little protection is provided. There is some evidence of deteriorated wood where there has been direct exposure to the elements. Continued deferral will not be cost effective due to further deterioration and corrosion, and more extensive surface preparation will be required.

I. Michoud Assembly Facility (MAF)..... 990,000

1. Repair of Cooling Towers..... 360,000

This project includes the repair of three cooling towers, #127, #202 and #352, that support Shuttle operations at MAF. Two of the towers were constructed in the 1963/1964 time frame and the third dates from 1952. Towers #127 and #202 directly support the production of the External Tank (ET). Cooling tower #352 supports the cooling system of Building 350 that will house the engineering and management staff of both NASA and the prime contractor on the ET, as well as other Government tenants. Cooling tower #202 is a single "point-of-failure" for the chilled water system that is required to maintain the production plant environment within the limits required. The last major repair of this tower was in 1964. Some 30 to 50 percent of the structural members must be replaced. Loss of baffles and wall members (approximately 20 percent) have caused a serious loss in the energy efficiency of the unit. Repair of the structure and replacement of the fan motors will return the efficiency of the unit to its original capability. Cooling tower #127 supports both the cooling and process systems in Buildings 110 and 130. These systems in turn directly support production cells and/or equipment for the manufacture of the ET. Constant exposure to the condenser water has caused deterioration to structural members, heaters, wall decking and basins. This repair work will improve the energy efficiency of the tower and the systems it supports as well as its reliability. Cooling tower #352, like the other two towers, requires replacement of rotted decking, head boards and structural members. Walkways and platforms required to service the unit must also be replaced. In this unit the motors and fan gear boxes will be repaired. The distribution headers and basins will be repaired. In all three cooling towers the fire protection system will be inspected and repaired. Control systems will be adjusted or replaced. This work is badly needed to insure reliability of the towers for the ET production and improvement of the energy efficiency and reliability of the systems.

2. Repair of Asphalt Roadways and Parking Areas..... 210,000

This project is part of an integrated repair program of the asphalt roadway and parking area designed to maintain these surfaces with a minimum expenditure of funds. The unstable soil conditions in the New Orleans area, with the large amount of rainfall and high temperature, contribute to a rapid deterioration of the roadways and parking areas. Previously deferred funding of this project has resulted in greater effort now to return these surfaces to an acceptable standard. Further delay in repairing these surfaces could mandate complete rebuilding. In this phase of the project approximately 60,000 square yards (50,160 square meters) of roadways and parking areas will be overlaid with asphalt concrete, with the associated prime and seal coats. Roads and parking areas included are Jupiter Avenue from Mercury Boulevard to and including Lots L, J, G and C; and Saturn Boulevard from Mars Drive, east 900 feet (274 meters).

3. Repair of Various Buildings..... 420,000

This project provides for the repairs to the exteriors of the Main Manufacturing Building 103, Vertical Assembly Building 110, and the Laboratory Building 111, which are the major manufacturing buildings at MAF for the production of the External Tank. Steel surfaces of metal and asbestos siding have suffered wind and weather damage. Repair of the damaged sections and application of protective coatings to the exterior building walls and doors is required to insure the integrity of the buildings and prevent further deterioration which would require extensive replacement of siding and doors. Damaged or loose asbestos and metal siding shall be replaced or secured. Approximately 20,000 square feet (1,858 square meters) of metal surface require sand blasting with other areas to be scraped and cleaned. Protective coating will be applied to 320,000 square feet (29,728 square meters) of surface.

J. National Space Technology Laboratories (NSTL)..... 1,035,000

1. Repair to Navigation Lock and Bascule Bridge..... 350,000

This project provides for the repair of the NSTL Navigation Lock and Bascule Bridge. The work includes dewatering the lock in order to repair needed component hardware such as upper and lower gate seals, bearings, sills, grease lines, and cathodic protection system, as well as providing protective coatings as needed. Also included is the repair of tainter valves, gates and underwater piping. The dewatering process will require the placement of structures in the canal upstream and downstream of the lock in order to barricade water flow. A recent inspection has been performed and recommendations for these repairs has been validated. This indicates that the dewatering, inspection and underwater repairs must be accomplished by 1980. The lock has not had this type of overall repair since completion of construction in 1965. Operational failure of bridge and/or lock could impair delivery of cryogenics by barge which directly support the Shuttle Test Program. This bascule bridge is the only access to NSTL from the South.

2. Repair of High Pressure Gas System Valves..... 485,000

This project will provide for the repair of high pressure gas system relief valves within the Shuttle Test Complex, cross country systems and base facilities. The work includes valve rework, repair, and certification. The scope of this effort meets 1980 requirements only, and will be a major continuous cyclic repair program to be accomplished on a year-to-year basis. During the reactivation of the high pressure gas system for Space Shuttle Main Engine, a large number of these valves and system components were replaced. However, because of the heavy test load involving 2 to 4 test firings per week, and because these components are continuously subjected to very high pressure, the repair cycle is most important. Based on experience since the start of engine development testing, it became clear that such cyclic repair on many system components

would be required no later than each 4-5 years. Since the test program started in FY 1975, the initial phase of valve and component work will be necessary in FY 1980.

3. Repair of Diesel Engines..... 200,000

This project provides for the repair of fourteen diesel engines which drive high pressure water pumps and provide back-up power. There are 10 water pump engines rated at 4,460 horsepower each and 4 power generator engines rated at 2,120 horsepower each. These engines will have a detailed inspection, and the resulting repairs to include necessary replacement of parts and components will be accomplished in accordance with the manufacturers' recommendations and useage experience. These engines are necessary to support the Shuttle Engine Test Program. The ten diesel engines are used to pump high pressure industrial water to the test stand deflectors at a rate of 300,000 gallons per minute. The other four provide back-up power during test period in the event of commercial power failure. These engines have been subjected to heavy and continuous usage since their last major overhaul in 1974. Because of this heavy usage over the past four years, inspection and repair will be required during 1980. The test workload is such that engines must be serviced in sequence and thus will require a full year implementation cycle. The loss of any of the diesel engines would result in a compromise of the Shuttle Engine static firing program at NSTL.

K. Wallops Flight Center (WFC)..... 1,200,000

1. Repair of Airfield Facilities..... 440,000

This project provides for the most urgent repair of the airfield facilities. This work includes the repair of the deteriorated pavement and the overlay of four inches (10.2 centimeters) of bituminous concrete of approximately 12,800 square yards (10,702 square meters) of the south 800-feet (244 meters) of Runway 17/35. In addition, this work includes the repair of ramp areas around the Aircraft Control Tower, Building A-1, Fire Control Station, Building B-129, and the Fuel Tanks, E22 and E23, and the overlay with two-inches (5.1 centimeters) of bituminous concrete of approximately 29,000 square yards (24,247 square meters) of pavement. The related aircraft surface markings and improvements to the shoulder areas are included in this work. The repair of the airfield paving at the south end of Runway 17/35 and the ramp areas by Buildings A-1 and B-129 is necessary to maintain an acceptable surface quality that is conducive to aviation safety. Spalling is occurring in this area and the resulting loose debris is increasing the probability of damage to conventional and research aircraft. Surface markings are required to provide clear direction for aircraft ground control. The repair of these airfield facilities is necessary at this time to stop further pavement deterioration and more extensive and costly future repairs, and to provide adequate support for research aircraft operations.

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2. Repair of Roads..... 285,000

This project provides for the repair of the principal roads on the Center and the island launch area. This repair work includes the overlay of two inches (5.1 centimeters) of bituminous concrete on approximately 40,000 square yards (33,444 square meters) of the main entrance to the Center, Stubbs Boulevard, Fulton, Wormhoudt, Bond and Bliss Streets. The drainage of the island road will be improved and a two-inch (5.1 centimeter) bituminous surface course will be applied to approximately 8,500 square yards (7,107 square meters) of pavement. In addition, this work will include the related repair of the curbs, sidewalks, and shoulder areas of these roads. These repairs are the result of a study of the existing conditions of the primary roads of the Center. Since 1959, maintenance of the primary heavy traffic roads of WFC has been by sealing and other short term measures. Major repairs are needed at this time to correct settlement, protect the subgrade, and provide adequate drainage. The Wallops Island road is the only access to the launch facilities and it has deteriorated to a condition that this repair work is necessary to provide a suitable surface for the transportation of research rocket motors. Some additional repair effort will be necessary in future years for the remaining roads and parking areas of the Center.

3. Repair of Various Roofs..... 175,000

This project involves the necessary repair of the roofs on Buildings N-162, V-45, V-50, V-55, W-65, X-15, X-35, and X-85 at WFC. These repairs include the installation of new roofing, insulation and related work on some 75,500 square feet (7,014 square meters) of roof surfaces on these buildings. This repair project is the result of a study of the roof conditions at the Center. This study indicates the roofs of these buildings have deteriorated to an extent that the repair work is beyond normal maintenance, and a major repair effort now is necessary. Deferral of this repair project will require more extensive and costly repair work at a later date, with the potential of water damage to the interior furnishings and equipment of the buildings caused by leaks.

4. Repair of Steam and Condensate Distribution System..... 300,000

This project provides for the repair of the steam and condensate distribution system at WFC. The work includes the repair of approximately 5,600 feet (1,707 meters) of steam and condensate piping, valves, expansion joints, and related equipment. The existing steam and condensate system serving the principal buildings of the Center was installed in 1958 and has deteriorated to the extent that continual repairs are required to maintain the steam service. The repair of the steam and condensate distribution system will provide better steam service and conserve energy and water resources by eliminating the waste due to leaks. This repair project is needed at this time to reduce maintenance, improve operating conditions, and reduce the consumption of energy at WFC.

MISCELLANEOUS PROJECTS LESS THAN $150,000 EACH	1,350,000
TOTAL	12,000,000

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

It is estimated that between $10 and $15 million per year will be required for the continuation of this facility repair program. It must be recognized that this is the initial year for a centrally managed repair program and that prior experience with Rehabilitation and Modification Programs indicates that early requirements tend to be conservative and may be underestimated.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

SUMMARY

REHABILITATION AND MODIFICATION

	Amount (In dollars)	Page No.
Summary of Project Amounts by Location:		
Ames Research Center	1,725,000	CF 13-4
Dryden Flight Research Center	555,000	CF 13-6
Goddard Space Flight Center	1,440,000	CF 13-7
Jet Propulsion Laboratory	1,140,000	CF 13-9
Johnson Space Center	1,845,000	CF 13-11
Kennedy Space Center	315,000	CF 13-15
Langley Research Center	1,640,000	CF 13-16
Lewis Research Center	1,010,000	CF 13-17
Marshall Space Flight Center	2,050,000	CF 13-19
Michoud Assembly Facility	530,000	CF 13-21
National Space Technology Laboratories	550,000	CF 13-22
Wallops Flight Center	785,000	CF 13-23
Various Locations	3,805,000	CF 13-24
Miscellaneous Projects Less than $150,000 each	2,400,000	CF 13-25
Total	19,790,000	CF 13

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE:	Rehabilitation and Modification of Facilities not in Excess of $500,000 per Project
INSTALLATION:	Various Locations
	FY 1980 CoF ESTIMATE: $19,790,000
FY 1978: $18,900,000	FY 1979: $15,300,000

COGNIZANT INSTALLATIONS/LOCATION OF PROJECT: Various Locations

COGNIZANT HEADQUARTERS OFFICE: Office of the Comptroller

SUMMARY PURPOSE AND SCOPE:

This program is to provide for the rehabilitation and modification of facilities at NASA field installations and Government-owned industrial plants engaged in NASA activities. Included in this project are those priority rehabilitation and modification facility needs for FY 1980 that can be foreseen at the time of the submission of these estimates, and that are estimated not to exceed $500,000 per project. The purpose of this program is to protect, preserve, and enhance the capabilities and usefulness of existing NASA facilities, and to ensure the continued safe, economical, and efficient use of the physical plants. Each of the individual items contained in this year's request for facility rehabilitation and modification work is in itself a proper facility project. Each represents the consistent application of the approved and accepted definition, and, in this context, each includes all of the facility work that needs to be done in the budget time frame, or all of the facility work that can be done in that time frame, as limited by constraints other than availability of resources. Each individual item has been evaluated against applicable need dates, time lines, and the ability to place the planned work under contract in the budget time frame.

In addition to the usual rehabilitation and modification requirements to the physical plant, the Agency continues to emphasize the identification of projects that relate directly to the conservation of energy at the various field installations. This particular program is now specifically directed toward the general nonprogrammatic or institutional segments of NASA facilities; however, additional attention is also given to facility modification requirements generated by specific programs or projects.

The $19,790,000 request for FY 1980 is for those projects that must be done in direct support of critical programmatic and institutional requirements. This request also involves approximately $6.5 million for projects related to energy reduction which in itself testifies to the pressing nature of these needs.

PROJECT JUSTIFICATION:

At its initial cost, the existing NASA physical plant totals about $6.0 billion (September 30, 1978). A continuing program of rehabilitation and modification of these facilities is required to:

a. Protect the capital value represented by these facilities and to overcome the cumulative effects of wear and deterioration.

b. Ensure the continued and reliable availability of these facilities as well as their operational capabilities, as applicable.

c. Improve the capabilities and usefulness of these facilities in terms of NASA mission accomplishment, and overcome the aggregate effects of obsolescence.

d. Provide a better and safer environment for all personnel.

e. Provide for significant reductions in energy consumption through the initiation of energy conservation projects and the provision of updated and improved utility control systems.

This program includes only facility rehabilitation and modification work having an estimated cost not in excess of $500,000. The work is of such a nature and magnitude that it cannot be accomplished by routine day-to-day facility maintenance or by related routine facility work efforts that are provided for in other than CoF estimates. Rehabilitation and modification work estimated to cost more than $500,000 is reflected as a separate major CoF line item project. Not included in this project are the minor construction (new construction and additions) and repair of facilities projects that are required in FY 1980. Provision for these requirements are made under separate programs which are also included in these CoF estimates.

PROJECT DESCRIPTION:

Proposed rehabilitation and modification items for FY 1980 are outlined under "PROJECT COST ESTIMATE"; they total $19,790,000. This includes a total of approximately $3,545,000 which has been deferred from the FY 1979 program due to the budget reductions. This request is for projects that must be done in this time frame and their deferral would create high risks or consequences. These would impact on program schedules and critical institutional facilities requirements in support of Agency mission goals and objectives. Also included in this request are direct energy projects associated with buildings and other types of facilities.

Of the total projects listed, $17,390,000 represents separate projects at designated NASA installations. The remaining $2,400,000 relates to those smaller rehabilitation and modification projects estimated to cost less than $150,000, the nature and purpose of which are the same as for that work specifically delineated but which, because of their individual smaller sizes, are not listed separately. At this time, the projects in this total package are considered to be of the highest priority. They have been carefully selected from lists totalling about $47 million including $3,545,000 of pressing requirements deferred from the FY 1979 Program. This FY 1980 listing thus represents a modest increment in relation to the existing total backlog of this type of work for which provisions must be made over the next several years.

As indicated above, the projects in this request are considered to be of the highest priority on the basis of relative urgency and expected return on the investment involved. It is recognized, however,that during the course of the year some rearrangement of priorities may be necessary. It is also realistic to assume that a change in some of the items to be accomplished within the allocated resources may be required. For the purpose of justifying this estimated facilities rehabilitation and modification requirement, a tentative listing of projects is set forth under "PROJECT COST ESTIMATE." This work will be accomplished on a priority basis. The total of $17,390,000 of separate projects relates to the following broad categories of facilities:

a.	Utility Systems	3,790,000
b.	Fire Detection/Protection Systems	1,580,000
c.	General Purpose Buildings	6,085,000
d.	Technical Buildings/Structures	5,935,000

The additional lump sum estimate of $2,400,000 for smaller projects thus provides a total of $19,790,000 for this program.

PROJECT COST ESTIMATE:

A. Ames Research Center (ARC)..... 1,725,000

1. Modification to the 2x2-Foot Wind Tunnel, Building N-222..... 480,000

This project provides for the modification of the 2x2-Foot Wind Tunnel, Building N-222. This work includes replacing the four inadequate 1,000 horsepower (746 kilowatts) motors with four 1,500 horsepower (1,119 kilowatts) motors and the addition of an acoustic enclosure around the wing tunnel structure. This work also will include the modification of 2,000 square feet (186 square meters) of the test chamber. The existing four 1,000 horsepower motors are no longer able to supply the increased requirements of planned research programs. Many of the test program runs are now accomplished by operating at a 50 percent overload. The facility is shutdown often to cool the drive system, thereby delaying test program progress. Repair and maintenance requirements, resulting from the overload operation, are severely impacting research progress. During a period of over 12 months, one-third of the available test time was spent in motor repairs. Replacement parts for major components are no longer available. Recent environmental noise regulations require that the 2x2-Foot Wind Tunnel sound levels be reduced. The acoustic enclosure around the structure will reduce the noise level. The 2x2-Foot test chamber is inadequate for its present use. Modern electronic data equipment and other sophisticated test support equipment overcrowd the space. Modification of this space will provide for better utilization. The work in this facility supports rotorcraft aerodynamic performance programs, turbulent flow programs and airfoil aerodynamic programs. Significant testing and analysis is performed in relation to both subcritical airfoils. These modifications will allow for continuation of research in these areas.

2. Modification of the Radiation Facility, Building N-237..... 300,000

This project provides for modification to the Radiation Facility, Building N-237, Room 164, to accommodate the gas test cell now located in Building N-245, Room 182. In its present location, this cell is too close to personnel and is hazardous in the event of an internal explosion. Modifications include removal of old equipment in Room 164 and installation of a combustible gas monitoring system, a gas cell temperature sensing and control system, and new vacuum pumps. The gas test cell is used to determine the absorption of electromagnetic radiation in gases which are known or postulated to exist in the atmospheres of the outer planets of the solar system. The test cell consists of a 12-inch (30.5 centimeter) diameter, 82-foot (250 meter) long tube which has the capability to be charged with a gas of composition, temperature and pressure

representative of a planet's atmosphere. Building N-237 has several test rooms specifically designed to withstand an accidental or sudden internal over-pressure that might occur with an explosion or release of high pressure gas.

3. Modification of the Life Sciences Research Laboratory, Building N-239..... 300,000

This project provides for the modification of computer space in the Life Sciences Research Laboratory, Building N-239. This modification of 7,500 square feet (700 square meters) of space includes improvements to the electrical, mechanical and fire protection systems. A raised floor system will be installed in the computer area. New partitions and ceilings are included in the modification. This work is necessary to support the. Human Factors Research full mission simulation studies now being performed in Building N-239. A considerable portion of the computational equipment used in support of these programs has reached the end of its useful life and is being replaced. This project is necessary to support new computer equipment planned to be installed during the FY 1981 time frame.

4. Modification for the Airframe/Propulsion Calibration Laboratory, Building 207..... 425,000

This project provides for the modification of 1,800 square feet (170 square meters) of space in Building N-207. The Building's 1x3-Foot (.3x.9 meter) wind tunnel test section, aftercooler and return loop will be dismantled and removed. A calibration chamber will be fabricated and installed at the inlet side of the wind tunnel compressors as well as the installation of new exhaust piping. Room partitions will be added to divide the area into several rooms. A two-inch (5 centimeter) high pressure air line from the adjacent Hypervelocity Free Flight Facility, Building N-237, will be installed with provisions to attach an existing one megawatt portable air heater to the line. This modification is needed at this time to provide the proper pressure, environment and means to accurately calibrate the thrust and airflow characteristics of the advanced turbine powered propulsion simulators prior to testing in the 11-Foot Unitary Plan Wind Tunnel and the 12-Foot Wind Tunnel. These calibrations are required so that aircraft drag can be obtained prior to wind tunnel measurement. No facility presently exists to perform these tests. Since the calibration for each simulator is unique, specialized equipment is needed. Because of the unique tests, performing this testing at another facility would become prohibitive.

5. Modification of HVAC Systems In Various Buildings..... 220,000

This project provides for the modifications of the heating, ventilating, and air-conditioning (HVAC) systems in five buildings to improve the operating conditions. The buildings to be modified are the Administration Building, Building N-202; Headquarters' Army Research and Technology Laboratory, Building N-207; 40-Foot x 80-Foot Wind Tunnel, Building N-221; the Unitary Plan Wind Tunnel, Building N-227; and the System Development Facility, N-242. Modifications will include improvements to the controls, ductwork, timers, and other related equipment to permit building zoning for specialized equipment and more efficient utilization of energy. Also included will be provisions for economizer systems for the buildings which operate on a 24-hour, seven-day per week basis. This work will result in more efficient utilization of energy and produce an annual savings of 1,890,000 kWh of electricity resulting in a simple payback of approximately 5 years.

B. Dryden Flight Research Center (DFRC)..... 555,000

1. Modification of Fire Water System..... 255,000

This project provides for the modification to the water system at the Dryden Flight Research Center (DFRC). This work will include the installation of a new 500,000-gallon (1,890 kiloliters) welded steel ground water storage tank near the existing pumphouse, Building 4853. The new water storage tank will be connected to the adjacent existing 20-inch (51 centimeters) diameter water supply system. The existing and new valving and piping will be arranged to permit the existing two 5,000 gpm (189 kl pm) diesel engine pumps in Building 4853 to supply water to the main building complex and the flight test area. The existing water supply system for the Center is provided by a single 20-inch (51 centimeters) underground fire protection main of approximately 11,800 feet (3,600 meters) in total length to the storage reservoir. If the 20-inch (51 centimeters) main breaks at any point in its almost one mile length between the main complex and the reservoir, there will be no fire protection water available to the Center. The installation of the 500,000-gallon (1,890 kiloliters) water reservoir is more economical than the construction of a second or "loop" water main, and will provide more than the minimum water storage requirements for an adequate level of fire safety.

2. Modification of Utility Control Systems..... 300,000

This project provides for continued facility modifications of the Utility Control System (UCS). The modification work includes the installation of a central station minicomputer and operator's console to be located in the Research Development and Test Facility, Building 4800. The utility systems that will be monitored and controlled include heating, ventilating, air conditioning, lighting, electrical power, and fire detection in various buildings. The existing centralized surveillance monitoring and fire alarm detection systems will be integrated with this UCS. The installation of sensing and control will conserve energy resources, and

reduce maintenance and operating manpower, thus contributing to better management of the Center's facilities within energy reduction goals and manpower guidelines. This effort has a simple payback period of less than three years.

C. Goddard Space Flight Center (GSFC)..... 1,440,000

1. Modifications for Fire Protection and Safety..... 460,000

This project provides for the modifications to various facilities so as to achieve an improved level of fire protection and safety. This work includes the installation of automatic sprinkler protection in portions of 24 buildings totaling approximately 200,000 square feet (18,580 square meters). This project completes the installation of automatic sprinkler protection for all buildings. The Center requires a high level of installed fire suppression to provide an adequate level of protection for the high value electronic and research equipment, scientific experiment development, spacecraft operations control centers, and the NASA-wide tracking and communications center. This level of installed fire protection is necessary to protect the research equipment during periods when the buildings are unoccuppied. In addition, the fire protection services are provided from an off-site organization and the nearest component is located approximately two miles (3.2 kilometers) from the Center. This work was not accomplished in the areas involved when the remainder of the building was provided with sprinkler protection since the utilization did not warrant the investment in sprinkler protection. Modification and improvements to these areas have changed the conditions and automatic sprinkler protection is now required.

2. Modification of Air-Conditioning Systems, Building 3..... 240,000

This project provides for the modifications to the air-conditioning systems in the Central Flight Control and Range Operations Laboratory, Building 3. This modification of two of the most inadequate air conditioning systems will be accomplished by the installation of new equipment of greater capacity. In addition, a new air handling system will be installed to provide a suitable environment for the computer equipment which has been installed in space originally planned for offices. Building 3 was built in 1961 to provide laboratory and office space for spacecraft mission tracking, data reduction, operations, and control. Since that time, several modifications have been made to the air-conditioning systems to provide for installation of additional computers and related equipment to support new spacecraft programs. The existing systems now are unbalanced, inadequate and require extensive maintenance. This project is the initial effort of a planned program to correct these deficiencies and must be accomplished at this time to insure continued operation of the facility. The computers and control centers operate twenty four hours a day, seven days a week. Modifications to the air-conditioning systems must be planned and accomplished while continuing the real-time tracking and control

operations conducted in Building 3. The completion of these modifications will permit further improvements to the air-conditioning system to support planned free flyer spacecraft program operations in this vital facility effectively.

3. Modifications for Energy Metering..... 350,000

This project provides for the modification of the utility systems serving 19 principal buildings by the installation of steam and condensate meters. The steam system serving 18 buildings which has a peak steam flow rate of over 1,500 pounds (680 kilograms) per hour will be modified to include steam and condensate flow meters. In addition to these buildings, steam and condensate meters will be placed in the three major steam supply lines from the Central Heating and Refrigeration Plant, Building 24, to the buildings. This project is the result of an analysis of the steam consumption and services lines of 23 principal buildings and Building 24 at the Center. This analysis determined the need for additional means in order to monitor the consumption of steam in these 19 buildings for effective energy management. The installation of meters in these facilities will provide the capability of monitoring energy consumption in each building and will enable the identification of high energy consumption problem areas. These meters will provide verification of the results of corrective energy conservation measures and the capability to make final adjustments in building system operation to optimize energy utilization.

4. Modifications to Various Buildings..... 390,000

This project provides for the modifications to the electrical and heating, ventilating and air conditioning (HVAC) systems in various buildings. The electrical modifications include the replacement of 1,020 incandescent lighting fixtures with 670 fluorescent fixtures in the Network Test and Training Facility, Building 25. Included are the related modifications to the electrical power system and the replacement of approximately 33,000 square feet (3,066 square meters) of ceilings. The electrical modifications included the installation of 55 light sensing photo cells in the lobbies and stairways of some 15 buildings to turn off unnecessary lights. The HVAC distribution system for cooling computer spaces in Building 25 will be modified to eliminate reheating by mixing the return air with conditioned air and installing additional cooling coils. The HVAC system will be further modified by replacing seven electric reheat coils with a hot water modulating system. This project is the result of a survey of the electrical and environmental control systems of 21 major buildings of over 30,000 square feet (2,787 meters) at the Center to improve operating conditions. These modifications to the electrical and HVAC systems were selected to improve the working conditions and system operation, are cost effective, and will reduce energy consumption and maintenance costs. This work is estimated to result in an annual savings of 4,500 gallons (17,032 liters) of fuel oil and 1,356,000 kWh of electric power with a payback of 4 years. Further modifications to the HVAC system in various buildings and the central heating and hot water systems are being investigated and may be considered as a future years project.

D. Jet Propulsion Laboratory (JPL)..... 1,140,000

1. Modifications to Space Flight Operations Facility, Building 230..... 225,000

This project provides architectural, electrical and mechanical modifications of approximately 20,000 square feet (1,858 square meters) of space required for the consolidation of "real time" computers, operations, operations control and related support areas to the first floor of Building 230. This work is a part of the overall plan for improving the Space Flight Operations Facility for more efficient support for future flight projects. The many computers which comprise the computing system for real time operations are currently scattered throughout Building 230. In order to provide for economy of operations of these systems, they must be physically consolidated. This is especially important as flight project tasks progress into longer term operations support. Locating real time operations onto the first floor of Building 230 will result in a more stable usage plan for the building and provide the long term result of minimizing reconfigurations and reducing manpower requirements. The work will support Voyager Saturn encounter, Galileo and future projects.

2. Rehabilitation of 25-Foot Space Simulator System, Building 150..... 495,000

This project provides for the rehabilitation of the present instrumentation system in Building 150 by providing a new data system that will be configured with remote terminals and will serve as a central data handling system serving the other test areas with adequate data acquisition and processing capability. The new system will measure the output voltage of up to 1,000 separate data sources as well as acquire digital data from spacecraft telemetry. The data received will be handled through a large data processor and also processed in real time to provide outputs on data display devices. This system will provide unit level redundancy to allow simultaneous multi-test operation and will have the capability of storing temporary data to provide trend analysis. Simulation of space and solar environment for testing spacecraft at JPL is done in Building 150 Space Simulator Facility. Because of the large number of measurements required for testing of this type, a data acquisition system is also required. Basically, the data system's function is to record and display those parameters that describe the spacecraft's environment and the spacecraft's response to that environment. This requires the capability to record large quantities of data over relatively long periods of time, displaying periodically or on demand that information needed to monitor test conditions. It must also have the capability to be programmed to annunciate out-of-tolerance conditions of preselected parameters.

Reliability of the system is of the greatest importance. Failure of the system could mean loss of temperature control and damage to the spacecraft. A failure could cause a test delay or even necessitate a retest which would cost about $24,000 for each additional day of testing.

The present data system has become unreliable. It was installed in 1969 and has had approximately 25,000 hours of operation. The digital tape recorder, high-speed printer, and digital logic elements are no longer in production and spares are not available and there is no back-up hardware in this system. During the Voyager spacecraft thermal control test the data system failed in ten independent modes, all attributable to the aged condition of the equipment.

The present system has only the capacity of monitoring 500 channels and recording about 750 channels; this is too limited for the present day requirements. The existing capability for processing data while a test is in progress is extremely inefficient. A Data Acquisition System that will make measurements of the output voltage of up to 1,000 separate data sources and acquire digital data from spacecraft telemetry is required. The system is needed for the Galileo project and the Infrared Astronomy Satellite (IRAS) and Solar Power projects. As previously stated, a high probability of failure exists each time the existing system is used. These failures will result in time delays and great financial losses due to test delays and retests, damage to the spacecraft, and flight schedule delays. The inadequacies of the existing system require that this rehabilitation work be accomplished in order that this Space Simulator Facility can effectively/efficiently support research mission requirements.

3. Modifications to Materials Research Processing Laboratory, Building 158..... 170,000

This project provides for the facility modifications of 715 square feet (664 square meters) of laboratory space in Rooms 101C and 101G of Building 158 to a clean room environment for the purpose of producing hybrid circuit elements. A controlled atmospheric furnace and chemical fume hood will be installed in Room 101G along with a filtration and purge system. Room 101C will have local filtration hoods, air exhaust hood, 40 linear feet (12.2 meters) of laboratory benches with overhead air supply, 26 feet (7.9 meters) of wall mounted cabinets, several microscope-type bonding, welding and inspection stations, a new "clean" floor covering plus drop ceiling throughout the entire area. The light arrangement will also be revised. The area of hybrid electronics deals with the vast practical development of discrete elements and assembled boards/components below the system level and is continually increasing its range of application in spacecraft electronics systems. The JPL development tasks aim at specific new materials, fabrication techniques or feasibility demonstrations so that contract requirements can be intelligently established for vendor fabricated spacecraft elements as well as in-house instrument devices/systems. In addition to maintaining an "up-to-date" limited volume in-house fabrication capability to support this prototype development, another major effort involves evaluation, failure analysis and emergency repairs to flight qualified components. These latter functions are often required on a "crash" basis during last minute spacecraft checkout at the Spacecraft Assembly Facility or at the Kennedy Space Center. Vendor support is usually administratively or technically unable to meet project schedule restraints and JPL must solve the technical problems and perform the necessary repairs in time. Historically, this effort has required the flight project office to waive all quality assurance and cleanliness requirements, as placed on

the original vendor, so that the work could be done at JPL. This proposal effectively cleans up the existing facility area so that the product can be considered of flight quality.

4. Modifications to Boiler Rooms, Various Buildings..... 250,000

This project provides for the modifications to various boiler rooms and the relocation of heating equipment therefrom to achieve compliance with existing mechanical codes and to eliminate potential safety problems due to improper sources of combustion air. The situation in three buildings (the Engineering Office Building 138, Solid Propellant Engineering Laboratory Building 197, Telecommunication Building 238) can be corrected by the addition of automatic fire doors and ventilation duct fire damper to effect separation of the boiler areas. The Fabrication Shop Building 103 will require enlargement of its attached boiler room and the consolidation of two small boilers into a single larger unit. The Environmental Laboratory, Building 144 will require the installation of a new boiler, hot water pump(s) and related piping/breeching. Relocation of the new diesel fuel tank to the same vicinity is also required. At the Space Sciences Instrument Systems Laboratory, Building 168 both the boiler and the domestic hot water heaters must be removed from the existing mechanical rooms and mounted on a newly constructed overhead deck between Buildings 168 and 169 where access to services and existing piping is reasonable. In effect, an external boiler room of less than 300 square feet (28 square meters) is created over the loading dock as there is no physical or economically viable solution within the confines of either existing buildings.

This project is required to bring the referenced buildings into compliance with existing mechanical codes which does not permit boilers to be located in machinery rooms containing refrigeration equipment. Leakage of "Freon" type refrigerants in the presence of moisture, produces accelerated corrosion of ferrous material, while exposure to flame temperatures in excess of 800°F (426°C) results in chemical changes that generate poisonous gases. This project will eliminate the most significant potential hazards of this type at the Jet Propulsion Laboratory.

E. Johnson Space Center (JSC)..... 1,845,000

1. Modifications for Life Sciences Experiments Development and Integration Facility, Building 36..... 405,000

This project modifies approximately 13,000 square feet (1,208 square meters) of the high bay wing of the Bioengineering and Test Support Facility, Building 36. This will provide a Life Sciences Experiments Development and Integration Facility. The work includes modifications to high bay, shop, office, laboratory, and class 100 clean room areas in the building. Approximately 6,000 square feet (557 square meters) will be modified to provide new class 100,000 clean areas to support integration, mockup, and checkout functions. The

area around the integration mockup will be provided with support utilities. R&D funded computers will be installed on the second floor and necessary computer flooring, air-conditioning, and support utilities will be provided by this project. Minor modifications in the existing class 100 clean room will be provided for "mini-lab" buildup. High pressure bottle manifolds and vacuum pumps will be provided adjacent to the building. Utility trenches will be modified by adding high pressure utilities, compressed air, vacuum, sanitary sewer, and cable trays. An existing "laydown area" will be modified by extending existing utilities to provide a trailer parking area to house the animal specimens used in several of the proposed experiments. Areas adjacent to the class 100 clean room will be generally modified and upgraded by painting, relocating power and telephone receptacles, and replacing floor and ceiling tiles. This project is required to support the NASA Integrated Life Sciences Experiment Program. The Johnson Space Center has been designated as the lead project management Center and is responsible for the development of experiments and for the integration of all NASA life sciences experiments. Under this project, experiments and/or equipment developed at Ames Research Center or other laboratories will be shipped here and the equipment will be combined with JSC developed items for integration into the Shuttle spacelab. Following this activity, the life sciences payload will be shipped to KSC for further integration and launch into space. To carry out this task, JSC requires a facility for both development and integration of life sciences payloads. This project will provide space for development, test, integration, checkout, and crew training with flight equipment. The facility will also be used for shipping and receiving; equipment storage; specimen examination, test and holding; experiment test and checkout; component integration, and science data monitoring. This will be the only NASA facility available to allow crew members and support teams to train in a "hands on" environment operating the life sciences experiments in an operational mode. Present plans are to support one dedicated spacelab payload every 18 months beginning late in calendar year 1981 through calendar year 1991. Additional "mini-lab" and "carry-on" laboratories will be supported as approved by the program. To support laboratory preparation activities, all construction activation and checkout must be completed in calendar year 1980.

2. Modifications to the 20-Foot Diameter Altitude Chamber, Life Systems Laboratory, Building 7..... 320,000

This project provides for modifications to the 20-foot diameter altitude chamber in the Life Systems Laboratory, Building 7, to support system testing. Certain changes to the chamber interior are required to accommodate the regenerative subsystem test articles on the ground level of the main chamber compartment and to provide for a large isolated volume for gas mixing in the top of the chamber. Modifications to the lower level crew bay area are also needed. This will include modifying the facility open loop environmental control system for sea level operation; installation or relocation of an emergency station inside the chamber, elimination and/or relocation of ultraviolet, thermal, and smoke detectors; and relocation of power distribution cables, power outlets, crew bay lights, and additional lights and controls. The upper portion of the 20-foot chamber will be modified by installing a new pressure tight ceiling above the crew bay compartment to create a leaktight

mixed gas tank. This new ceiling will meet the pressure vessel requirements of several inches of H_2O above sea level and will have an access port for installation and maintenance. The Government furnished air supply unit with mixing fans, chiller/heater package, and trace gas injection system will be installed on an exterior platform adjacent to the chamber. The air supply unit ducting will interconnect with the gas chamber and test articles. Operating controls and/or support systems necessary to operate the in-chamber hardware will be provided externally to the chamber.

The 20-foot chamber complex presently has the capability to evaluate closed loop, regenerative life support systems (RLSS) under manned conditions. However, changes to the current 20-foot chamber interior are necessary to support future space programs which will require long duration operation by man in space. Expendable systems are weight prohibitive, therefore, a secure technology base in RLSS is required. The goal of on-going technology programs is to demonstrate that regenerative life support processes have achieved a state of technological readiness capable of supporting man reliably during long term space missions. A key step in the development of this technology readiness will be the manned ground verification tests of an RLSS prior to commitment to a flight hardware program. Shuttle launched flight opportunities for an RLSS in the mid-1980's include a life sciences dedicated spacelab or a space habitability module. The ground test program will require all elements of the RLSS to be packaged and operated in a flight-type configuration to assess integrated system performance and man/machine interfaces. By modifying the chamber, the large volume of the chamber can be used to house the test crewmen in a controlled sea level environment and also to provide an adjacent but separate test volume in which the conditions can be subject to the operation of the closed loop RLSS without endangering crew safety. The concept of having the crewmen perform all operational tasks associated with living on an RLSS while a space environment is maintained, allows emergency and/or unexpected situations to be simulated. In addition, to accurately evaluate overall efficiency of the closed loop system and quantify low level subsystem leakage for an atmospheric composition balance, a relatively large, isolatable test area is required. Modifications to the 20-foot diameter altitude chamber is the most economical method available to accomplish these developmental objectives. Initial hardware is scheduled to be delivered in February 1980, and installation must begin in October 1980, to meet an August 1981 operational date.

3. Rehabilitation and Modification of Heating, Ventilating, and Air-Conditioning (HVAC) Systems, Various Buildings..... 475,000

This project is a portion of a long-range program for rehabilitation and modification of HVAC systems in various buildings at JSC. The modifications include installation of new control systems for the air handlers in Buildings 11 and 14, and the rework of fan and filter sections of an air handler in Building 16 to permit filter changes with the unit operating. Rehabilitation work will also be accomplished in 14 other buildings. This latter work includes repair and/or replacement of steam stations, condensate return units, valves, pumps, compressors, condensors, coils, air handler casings and structures, and fan assemblies; calibration of

instrumentation; and insulation and painting of ancillary equipment. This rehabilitation and modification work is required to provide for the more efficient operation of the heating and cooling system controls in Buildings 11, 14 and 16. Various heating and cooling system components in the other buildings are rapidly deteriorating and approaching the end of their life expectancy and, consequently, most of the residual work is essential now. Effective energy conservation requires that these systems operate within specifications. A system's performance efficiency is attainable only when components are in good condition.

4. Modifications to Blowdown Water Treatment Facility, Building 223, Sewage Treatment Plant..... 180,000

This project will provide for modifications to the existing cooling tower "blowdown" water treatment facility. The work includes a new filtration system with automatic backwash capability that will have the capacity to process up to 150 gallons per minute of influent. The caustic soda system will be modified by replacing one of the existing chemical feed pumps with two larger units. Heaters will be installed on the existing caustic soda storage tank to maintain the liquid at a minimum temperature of 70°F. The existing sludge drying beds also require modifications to improve sludge removal. A flow control device will be installed at Building 24 (Central Heating and Cooling Plant) to provide constant flow of blowdown water to the treatment facility at the Sewage Treatment Plant. The existing facility for treating blowdown water from Building 24 cooling towers was designed in 1974 to comply with the then current Texas Water Quality Board (TWQB) requirements for hazardous metal content of facility effluent. Since that time, the TWQB has introduced an "order-of-magnitude" reduction in the maximum permissable content of chromium that can be contained in the effluent to less than 0.5 parts per million (ppm). The existing facility reduces the chromium and zinc content of the effluent to well below the allowable limits of the 1974 regulations. However, the effluent from the facility will not consistently meet requirements of present TWQB discharge requirements or conform with the potential Environment Protection Agency requirements for control of heavy metals discharged at a point source. Implementation of these modifications will provide a facility that will meet all existing and projected requirements for control of heavy metals discharged at the point source.

5. Modification of Air-Conditioning Systems, NASA Industrial Plant, Downey, California..... 465,000

This project provides for the modification of existing air-conditioning systems in various buildings at the NASA Industrial Plant, Downey, California, for the purpose of energy conservation. The work includes modifications and/or additions to the control systems, ductwork, dampers, and insulation to provide "economy cycle" operation for all air handlers in Buildings 001, 009, 287, 288, and 290, plus 17 air handlers in Building 006. "Economy cycle" operation affords the optimum utilization of the outside ambient atmospheric conditions. When cooling is required in a building and the outside conditions are cooler than those inside, the cooler

outside air is drawn into the building to provide all or part of the required cooling. The same principle is followed to satisfy the requirements for heating. The modification of air handlers for the "economy cycle" operation capability will reduce natural gas and electricity consumption by a total of 129×10^9 Btu annually resulting in a payback of approximately 1 year. This, then, is a primary energy reduction project which should be accomplished at the earliest date.

F. Kennedy Space Center (KSC)..... 315,000

1. Modifications to Nitric Acid Storage and Pumphouse Facilities to Provide Chemical Waste Treatment Facility..... 315,000

This project will provide for the modifications to the Nitric Acid Storage (1050B) and Pumphouse (1050A) facilities on the Cape Canaveral Air Force Station (CCAFS) to provide a chemical waste treatment capability. The 4,860 square foot (451 square meter) acid storage facility will be modified to include a chemical processing area to house equipment, including nine holding tanks, two processing tanks, two pressure tanks, four chemical feeders and tanks, two filter presses, eight mixers, two sludge pumps, a gaseous nitrogen system and necessary wiring, controls, piping and valves. The 439-square foot (41 square meter) pumphouse will be modified for a supporting office area and chemical laboratory.

This project is necessary now in order to comply with Federal and State legislation regarding water pollution, air pollution and land fill. The facility will provide an adequate level of treatment so that the produced effluents, emissions, and sludges will not jeopardize the quality of the physical and biological environment and will be responsive to the National goal of eliminating the discharge of pollutants into navigable waterways by 1985. This facility will provide treatment for chemical wastes in categories 8, 10, and 12. Category 8 wastes are comprised of acidic, basic or aqueous solutions contaminated with metal ions, category 10 wastes are acidic, basic and miscellaneous materials in aqueous solutions and category 12 wastes will be derived from the oxidizer vapor scrubbers used to reduce the sodium sulfate gases generated during the Shuttle loading and deservicing operations. Category 8 and 10 wastes are presently treated at an Air Force pumping station at the northeast tip of CCAFS. The United States Air Force has a National Pollutant Discharge Elimination System (NPDES) permit for this facility which expires in August, 1980. The continued operation of this pumping station is contrary to the National goal of eliminating the discharge of pollutants into navigable waterways; therefore, it will be closed when this facility is completed. Approximately 1,000,000 gallons of category 8 wastes are generated annually by the combined KSC and CCAFS operations. Though presently in small quantities, the cumulative total of category 10 wastes is estimated to be approximately 9.5×10^4 gallons through 1991. There are presently no facilities for treating the category 12 waste solutions to be generated by the vapor scrubbers. The volume of category 12 wastes generated by the oxidizer vapor scrubbers is estimated to start in 1979 with 4,500 gallons per year and increase to approximately 103,000 gallons per year in 1985 through

1991. The wastes will contain Na_2 SO_3, NO_3 and significant amounts of hydroxylamine sulfate and/or related compounds. This project will result in a facility capable of treating these chemical wastes which are derived from such functions as photographic laboratories, Shuttle payload and other institutional programs.

G. Langley Research Center (LaRC)..... 1,640,000

1. Rehabilitation of Electric Power Distribution System..... 385,000

This project provides for the rehabilitation of two (2) 110 KV circuit breakers in the Stratton Road Substation (Building 1233), the installation of sections of underground electrical ducts between the main Stratton Road Substation (Building 1233) and three primary substations--Taylor Road Substation (Building 1147), Ames Road Substation (Building 1247F) and Moffett Road Substation (Building 1266)---and the replacement of sections of existing 22 KV feeders "2J" and "2P1." A total of 1,600 linear feet (488 meters) of duct banks, 1,600 linear feet (488 meters) of feeder "2J" and 1,700 linear feet (518 meters) of feeder "2P1" will be installed. Feeder "2J" runs from Building 1233 to the proximity of the 16-Foot Transonic Tunnel (Building 1146) and feeder "2P1" runs from Building 1233 to Building 1147. Several sections of the duct banks between the above substations are nearly full. Installation of these new duct banks is necessary to meet the continued demands placed on the electrical distribution system. Feeders "2J" and "2P1" have corroded as a result of their exposure to the brackish environment encountered in the underground duct system. These lines were installed in 1947 and require replacement in order to allow for safe operation of facilities. The breakers must be replaced to coordinate their safe interruption operation under fault with available power company short-circuit values.

2. Modification to the 55-Foot Vacuum Chamber, Building 1293B..... 460,000

This project provides for the modification of the 55-Foot Vacuum Chamber by the installation of 250 KW of electric powered quartz lights. They will be arranged in banked assemblies and mounted around the chamber walls with individual electrical controls so that temperature differentials on the test specimens can be achieved. Located behind the test specimens will be a "cold plate" to simulate conditions of deep space in order to obtain higher temperature gradients across the test specimens. An existing hydraulic vibrator will be used to excite a new rotating table upon which a model will be mounted in order to duplicate programmed vibration levels. This facility modification is essential for the successful completion of planned long-range large space structures research efforts. Existing facilities have neither the physical size nor the controlled thermal vacuum vibration capabilities to conduct essential controls and dynamics research work in the early 1980's. Based upon the requirements for the Large Space Structures Program, these facility modifications are the most cost effective means of meeting the requirements.

3. Rehabilitation of Steam and Condensate Lines in the Utility Tunnel..... 370,000

This project provides for the modification of the steam lines in Utility Tunnels 1, 2, 3, and 4 for a more cost effective energy operation. This modification work will include the addition of about four inches (10.2 centimeters) of fiberglass type insulation on approximately 12,000 linear feet (3,660 meters) of existing steam and condensate lines in four underground tunnels. The existing magnesium oxide insulation on the lines varies from two to four inches (5 to 10 centimeters) of thickness. At the completion of this work, all lines will have a minimum of six inches (15 centimeters) of thickness, except where it is not possible to achieve this thickness. The existing lines were installed at a minimum initial cost with a minimum of insulation. The insulation thickness at that time was adequate since it was compatible with the lower energy costs, and the main interest was low initial capital cost. An assessment of these utility tunnels has been made in order to realize improved energy conservation. These modifications will save approximately 20×10^9 Btu's annually in fuel oil consumption resulting in a simple payback of less than six years.

4. Rehabilitation of the Data Reduction Center, Building 1268 and the Flight Control Research Laboratory, Building 1268-A..... 425,000

This project provides for the rehabilitation of electrical and mechanical equipment in the Data Reduction Center, Building 1268, and the Flight Control Research Laboratory, Building 1268-A. This work consists of zoning electrical power and chilled water systems to reduce the impact of utility failures. In addition, the building fire, chilled water and electrical alarm systems will be consolidated into an automatic central alarm system. The building steam supply, which is necessary for humidity control, will be tied into a second trunk line. Decentralized electrical and chilled water connections are necessary to prevent multiple system power loss. The automatic central alarm system will reduce the time necessary to maintain and monitor a large number of individual indicators. This will allow for the improved safety of both the personnel and equipment in the event of a failure or fire. Additional work will include the structural and architectural rehabilitation of Building 1268.

H. Lewis Research Center (LeRC)..... 1,010,000

1. Rehabilitation and Modification for Utility Control System..... 350,000

This project provides for the rehabilitation and modification of the existing utility systems and the utility control system (UCS) at LeRC to enable more cost effective, reliable, and energy conservative operations. This USC work includes the installation of a backup minicomputer and related peripheral equipment, a data plotter, and an uninterruptible power supply for the UCS master control station located in Building 21. Also provided are data acquisition control panels and sensors in ten buildings. The present LeRC UCS accomplishes

real time control of the various building utility systems and provides security surveillance of Building 500. This project will result in major energy savings in the buildings included by optimizing the operation of their heating, ventilating, and air conditioning systems. The minicomputer included will enable continuous operation of the entire UCS during malfunction or shutdown of the existing main computer. The uninterruptible power supply will facilitate programmed shutdown of the UCS during electrical power failures. The data plotter will enable fast and direct printout of the UCS computer stored information for assessment of the UCS operation and the Center's energy usage. In addition to providing increased UCS reliability and conserving energy, this work will reduce the building utility system operation and maintenance manpower requirement and provide additional system performance data for effective management of the Center's utility systems. The estimated simple payback for this project is three years.

2. Modification of Building Utility Systems..... 225,000

This project provides for the modification of steam, electrical, and chilled water utility systems in various buildings having over 30,000 gross square feet (2,790 square meters) each. Included is the installation of metering devices which are basic to energy conservation programs. This work is necessary to establish accurate values of energy consumption, evaluate the efficiency of the various systems and help identify cost effective energy saving initiatives. The work includes: (a) composite metering for office, technical facility, and laboratory Buildings 3, 4, 77, 86, 125, and 500/501, (b) steam metering for institutional Buildings 14, 50 and 64, and (c) chilled water metering in primarily institutional Buildings 6, 14, 21, and 60. Because the buildings selected are representative of the other buildings at the Center, this metering will supplement an analytical in-depth energy analysis of all LeRC buildings. This modification work must be accomplished as a prelude to future energy conservation improvements.

3. Modification of Propulsion Systems Laboratory Combustion Air System..... 435,000

This project provides a mechanical separator in the 72-inch (1.8-meter) combustion air tie-line from the Propulsion Systems Laboratory Equipment Building, Building 64, to Propulsion Systems Laboratory Test Cells 3 and 4 in Building 125. This separator will remove approximately 98 percent of all rust particles larger than 25 microns from the combustion air under all required flow conditions. The unit will operate from -50 to 600°F (-45 to 315°C) with air flows of 25 to 500 pounds per second (11 to 230 Kilograms per second) at pressures to 40 psig (28 newtons per square centimeter). Rust particles from the piping are presently carried by the combustion air stream into the research gas turbine test engines and associated instrumentation. The potential for engine failures increases as rust accumulations restrict turbine cooling passages and coat blades and vanes. Research operations are hampered by rust induced instrumentation problems such as plugged pressure probes, thermocouple failures, and destroyed strain gages. Removal of these rust particles as provided for by this project will reduce engine wear and instrumentation failures in addition to decreasing the possibility

of rust induced engine failures. This will result in more efficient research and energy conservation since repeating of research runs will be minimized.

I. Marshall Space Flight Center (MSFC)..... 2,050,000

1. Modification to Power System in Computer Facility, Building 4663, B Wing..... 250,000

This project provides for modifications to the existing power system serving primary computers housed in the Computer Facility, Building 4663, B Wing, by installing an uninterruptible power supply system. This system is to be comprised of static rectifiers, static inverters, lead-calcium batteries, electronic oscillators and controls, capacitors, circuit breakers and other electrical components which will provide approximately 250kw for a five-minute duration upon interruption to the commercial power supply. Computers housed in Building 4663 support all major Center programs in such areas as trajectory calculations, structural analysis, and real time data reduction and information systems. Inefficient computer operations impact the Center's ability to accomplish its assigned mission. Variations in the commercial primary electrical source cause unreliable computer operation. A variation of only a few cycles duration results in a loss of hundreds of bits of information with associated costs in lost productive operational time. Cost to restore operations after momentary electrical outages in the past two years has averaged $85,000 each year. The planned uninterruptible power system (UPS) will eliminate variations in primary power to computer equipment in all but the most unlikely cases with a payback of less than 3.5 years.

2. Rehabilitation of Central Fire Surveillance System, Communications Facility, Building 4207..... 450,000

This project provides for the replacement of the present fire surveillance programmable general processor, installed in 1969, with two redundant general processors and expansion of the present general surveillance of 85 to 90 buildings. Also included is the installation of an automatic fire suppression system in 13,000 square feet (1,207 square meters) of space located in Building 4207, in accordance with the NFPA Code. The existing equipment is obsolete, and has been modified and patched repeatedly to conform with changes in building configurations and status. Further modification is technically impractical and will seriously affect the system reliability. Conformance with the National Fire Code requires the installation of a redundant system. Replacement parts are not in production or available for the present processor, making maintenance and repair very difficult. The capacity of the present system is not adequate to provide central coverage of the additional buildings. Building 4207 is the communications center for MSFC; its function is vital to the accomplishment of missions assigned to MSFC. This building is not presently protected by a fire suppression system. Fire damage to expensive communication equipment would seriously interrupt Center operations and the transmission of test data.

3. Modifications and Consolidation of Surface Treatment Plant, Building 4760..... 450,000

This project provides for consolidation of existing surface treatment, cleaning, and plating activities; and for modifications to perform industrial waste treatment in Building 4760. The existing surface treatment area will be converted to a stand-by condition and a partition will be constructed between the surface treatment area and the plating area to allow for reduced ventilating and heating requirements. The plating area power, piping, heating and ventilating systems will be modified to accommodate a revised tank arrangement. Nine of the existing tanks in the evacuated surface treatment area will be utilized to provide for industrial waste treatment and three are to be modified to provide the pickle/passivation capability disrupted by the industrial waste treatment modifications.

The existing facility was sized for processing large items of space hardware at a high rate. The HVAC system was designed for 100 percent fresh air intake and runs continuously, seven days a week, 24 hours a day, for personnel health and safety reasons. Current planning and future requirements do not forecast the need for the facility as originally designed. MSFC has received an EPA discharge permit requiring that certain effluent limitations for industrial waste be maintained after July 1977. This project will meet these EPA requirements.

4. Modification of Materials Laboratory, Building 4612..... 450,000

This project provides for the modifications of approximately 23,400 square feet (2,173 square meters) of the Materials Laboratory, Building 4612, to accept laboratory and processing equipment, and office functions now located in Building 4711. The work will include modifications to the water, electrical, gaseous nitrogen, shop air, and air-conditioning systems. Also included are general repairs, some partition relocation and necessary painting. The closing of Building 4711 will involve the relocation of 50 people to Building 4612 with associated laboratories and equipment. The project is necessary to permit the consolidation of laboratory functions which will promote more efficient laboratory work in support of: Shuttle External Tank Improved Thermal Protection System Tests, Shuttle Growth Systems and Model Tests, Shuttle Flight Problem Solution Tests, Space Processing, Spacelab Development, Space Industrialization, Energy Research, Large Space Structures, and Space Telescope. The combined facility will result in better management control, eliminate duplication of equipment and result in a major energy and maintenance cost savings of approximately $180,000 per year. This project will bring together, into a central location, the highly qualified and experienced engineering and scientific personnel of the Materials and Processes Laboratory who have extensive experience in performing direct research and development work in material science, product/process engineering and materials application relative to design and development of space hardware and in space experiments.

5. Modification of Air-Conditioning System, Administration Building 902, Slidell Computer Complex..... 450,000

This project provides major modifications to the air-conditioning system serving Building 902. The work includes: reduction of excess air flow by deactivating and/or removing selected air handling units, rework of existing ducting, plenums, remaining air handling units, and raised flooring to meet current needs. Also included is the installation of new air handling units and modification to piping and control systems. The existing system was designed to provide maximum cooling and dehumidification for computer areas. However, a large portion of the original computer area has now been converted to office space, sitting on the old computer flooring. This has resulted in extensive personnel complaints due to the continued operation of the underfloor system for computer support. Further, the use of solid state circuitry in the computers has reduced the heat load in the remaining computer areas, and the principal requirement for the air-conditioning system is now for comfort. Therefore, these system changes are necessary, not only for personnel comfort, but also for energy conservation. The system was installed in 1962-1964 and, though operating well now, would be ready for replacement in the near future. Modifications at this time will result in an annual energy savings totaling over $106,000, and will have a payback period of approximately 4 years.

J. Michoud Assembly Facility (MAF)..... 530,000

1. Modification to HVAC Systems, Special Work Areas, Main Manufacturing Building 103..... 300,000

This project provides for modifications to the heating, ventilating and air-conditioning (HVAC) systems in the captive areas of Building 103, including the ET contractor, Weld Development Laboratory, Material and Process Laboratory, Shuttle Test Equipment (STE) Cable Fabrication Area, Tube and Valve Clean Area, Quality Assurance Lab and Meteorology Laboratory. The work includes installation of automatic and manual timers on the packaged air-conditioning units in the ET contractor area; installation of a 2-speed fan motor on an existing air handling unit in the Weld Development Laboratory with a time clock to shut down the air handler at night, also, conversion of the existing coil and reheat system in this lab to a demand system with humidity override; installation of an automatic time clock to shut down air handling unit during off-shift operations in the Material and Process Laboratory; installation of a 2-speed fan motor on an air handling unit in the STE Cable Fabrication Area along with an air by-pass control and an automatic time clock to shut down the unit at night; installation of 2-speed fan motors on seven air handling units in the Tube and Valve Clean Area, along with by-pass controls and ducting for return air, time clocks to shut down air handlers on off-shift operations, and automatic fan controls on a degreaser; installation of 2-speed fan motors on three air handling units in the Quality Assurance Laboratory along with by-pass controls for day/night operation and time clocks to shut down air handlers at night; and installation of 2-speed fan motors on four air handling units in the Meteorology Laboratory along with by-pass controls for day/night operating and time clocks to shut down air handlers at

night. Energy savings will be approximately 108 X 10^9 BTU annually resulting in a payback of less than 1 year. Consequently, this is a sound and prudent project.

2. Modifications to Lighting, Office and Engineering Building 350..... 230,000

This project provides for the removal and replacement of fixture lens', cleaning reflective surfaces, and relamping all light fixtures in all office and computer areas in Building 350. These fixtures and lens' have darkened and deteriorated with 14 years of age and require a complete cleaning and lens replacement to achieve the desired level of illumination for general office areas and to decrease the quantity of electricity required for that illumination. This project will result in an energy savings of 1,760,000 KWH annually for a payback period of approximately 3 years.

K. National Space Technology Laboratories (NSTL)..... 550,000

1. Rehabilitation and Modification to Main Cafeteria, Building 1100..... 170,000

This project provides for the rehabilitation and modification to the main cafeteria to include the removal of the existing dishwasher, vent system, work tables, spray and food waste disposer, and the installation of a new dishwasher, work table, soiled dish conveyor system, and waste disposal system. Also included will be modifications to the floor and drainage system in the kitchen and restrooms. These replacements are necessary to increase the serving capability from 600 to 1,000 meals per day, which has resulted principally from the addition of other Government organizations on-site as tenants. The existing soiled dish retrieving system is a manual operation which shows little or no planning in layout and/or operation. It has become evident that a conveyor system, along with a new, improved and relocated spray and waste disposal system is necessary to handle the additional personnel in a sanitary, efficient manner. The existing dishwasher is obsolete, deteriorated and too small to support the increased loading. The new dishwasher will be larger, will greatly reduce drying time and will not require a vent system. The floor drains are located at high points in the floor and the water must be manually mopped to the drains. Completion of this project will result in a labor reduction of one man-year in the kitchen area and capability to meet the total requirements of the increased population of NSTL in a fast, efficient and sanitary manner.

2. Modification of Interior Lighting Systems of Various Buildings..... 380,000

This project is for the modification of the interior lighting systems of Buildings 1000, 1100, 1105, 1200, 2204, 3202, 3203 and 8100 at NSTL to provide localized switching for individual offices and other areas. The system will be a low voltage lighting control system with low voltage operation of relays controlling the 277 volt AC power to the light fixtures. Work will also include the removal and replacement of approximately

5,000 polystyrene lens with low attenuation acrylic lens, and the disconnecting of approximately 1,600 fixtures. When these buildings were constructed 10-12 years ago, it was the general practice that, in the interest of fluorescent bulb life and economy and low energy cost, lights be left on 24 hours per day. Therefore, only minimum or no switching was provided, and only the panel circuit breakers located in mechanical equipment rooms can control the lighting. Most of these areas are off-limits to other than maintenance personnel. By providing room or area switching, many areas not in constant use can normally be switched off, thus reducing electrical consumption. Because of the higher light transmission of the acrylic lens, the replacement of the polystyrene lens with the more efficient acrylic lens will permit the disconnecting of approximately 1600 lamps which results in a lower power consumption. At the time of original installation, the only plastic lens available was generally of polystyrene, a material that yellowed very early and reduced lighting levels considerably. The simple payback for this project is less than 4 years.

L. Wallops Flight Center (WFC)..... 785,000

1. Rehabilitation of Headquarters Building, Building F-6..... 355,000

This project provides for the rehabilitation of 14,400 square feet (1,338 square meters) of the Headquarters Building, Building F-6, to improve the facility's condition. The exterior rehabilitation includes the installation of new doors and windows. The interior rehabilitation includes the installation of new lighting fixtures, flooring, ceilings, insulation, wall finishes, and revisions to the restrooms. This rehabilitation also includes the installation a new energy efficient central heating, ventilating, and air conditioning (HVAC) system. Building F-6 was constructed in 1946 and has deteriorated through aging and utilization. The mechanical and electrical equipment are antiquated and inadequate. This rehabilitation of the doors and windows, insulation, and the new central HVAC system will provide a more energy efficient facility. These improvements to this thirty-year-old building are needed at this time for more effective utilization of space, to save energy, and to provide better working conditions for the Center's personnel.

2. Rehabilitation of Instrument Service Calibration and Chemistry Laboratories, Building F-160..... 430,000

This project involves the rehabilitation of 11,800 square feet (1,093 square meters) of space in the southwest end of the Instrument Service Calibration and Chemistry Laboratories, Building F-160. This rehabilitation includes the installation of new partitions, ceilings, flooring, lighting, and the related electrical work. Related work to the mechanical and HVAC systems will also be included. This rehabilitation work will provide improved office and research support laboratory space. Building F-160 was constructed over 20 years ago for other purposes and in its present condition, is inadequate. This project is needed at this time for effective utilization of the space and to improve the working conditions.

M. Various Locations 3,805,000

1. Rehabilitation and Modification of Various Buildings at Goldstone Complex 260,000

This project provides for rehabilitation and modification of various buildings at the Goldstone Deep Space Communications Complex. The work will include rehabilitation and modification of roofs, walls and ceilings, vestibules, weather stripping and other associated types of work. The air-conditioning equipment will be rehabilitated with the installation of economizer cycles; ductwork will be modified to provide improved HVAC balancing, and obsolete control equipment will be replaced with more efficient control systems. Also, the lighting equipment will be modified from incandescent to fluorescent with reduced lighting levels, timer controls and daylight turnoff sensors. This project will rehabilitate buildings due to normal wear and tear, and will reduce operating and maintenance costs due to the reduction in maintenance, labor and spare parts. In addition, this work is required to insure that these buildings continue to support NASA missions in a reliable manner and at minimum operating costs. The costs of this project will be amortized by the savings in operations, maintenance and fuel costs.

2. In addition to the projects normally identified for inclusion in the FY 1980 program, the following is a listing of FY 1979 budgeted items which cannot be undertaken now due to reduction in appropriation and availability of other current resources for this type of work. The more definitive explanation of this work is the same as was included in the FY 1979 budget listing except for the inclusion of additional cost escalation to the FY 1980 time frame 3,545,000

a. Modifications to Spacecraft Operations Facility, Building 14, Goddard Space Flight Center ..... (480,000)

b. Rehabilitation of the Natural Gas Distribution System, Johnson Space Center ..... (210,000)

c. Modification of Heating, Ventilating and Air-Conditioning Systems in Building 1148, 1212, 1212B, and 1244, Langley Research Center ..... (315,000)

d. Rehabilitation and Modification of Library Services Building 60, Lewis Research Center ..... (490,000)

e. Modification of Propulsion Systems Laboratory (PSL) Equipment, Building 64, Lewis Research Center ..... (165,000)

f. Rehabilitation of Structures and Mechanics Laboratory, Building 4619, East End, Marshall Space Flight Center..... (420,000)

g. Rehabilitation of High Temperature Hot Water (HTHW) Generating System in Central Heating Plant, Building 3204, National Space Technology Laboratories..... (410,000)

h. Rehabilitation and Modification of the Technical Support Shops and Office Building, F-10, Wallops Flight Center..... (405,000)

i. Modification for Utility Control Systems at Goldstone Complex, Various Locations

(1) Pioneer DSS-11..... (265,000)

(2) Venus DSS-13..... (200,000)

(3) Apollo STDN..... (185,000)

The above projects must be considered on a high priority basis for accomplishment in the FY 1980 time frame to preclude deterioration of the basic facility plant. Deferral of these projects will cause further deterioration of the facilities identified resulting in increased energy/maintenance costs and decreased operational efficiency. In addition, the required work associated with these rehabilitation and modification projects will also increase in cost due to the future escalation of various construction wage and material prices. An additional concern is the higher potential of "unscheduled breakdowns" with their probable impact on missions. The further deferral of these projects will drastically tax the viability and effectiveness of this most essential Rehabilitation and Modification Program. This is especially so when considered in light of the already constrained facility maintenance and repair resources. Finally, the sequential deferral of these projects cannot help but have serious overall negative impact on this essential integrated program which is directed toward the preservation and enhancement of NASA's basic facility plant.

MISCELLANEOUS PROJECTS LESS THAN $150,000 EACH..... 2,400,000

TOTAL..... 19,790,000

It is estimated that between $18 and 22 million per year will be required for the continuation of this facility rehabilitation and modification program.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

SUMMARY

MINOR CONSTRUCTION

	Amount (In dollars)	Page No.
Summary of Project Amounts by Location:		
Ames Research Center	480,000	CF 14-2
Dryden Flight Research Center	325,000	CF 14-3
Goddard Space Flight Center	550,000	CF 14-4
Jet Propulsion Laboratory	1,145,000	CF 14-6
Johnson Space Center	120,000	CF 14-9
Kennedy Space Center	240,000	CF 14-9
Langley Research Center	415,000	CF 14-10
Marshall Space Flight Center	225,000	CF 14-11
Total	3,500,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE:	Minor Construction of New Facilities and Additions to Existing Facilities, Not in Excess of $250,000 Per Project
INSTALLATION:	Various Locations
	FY 1980 CoF ESTIMATE: $3,500,000
FY 1978: $5,950,000	FY 1979: $4,200,000

COGNIZANT INSTALLATIONS/LOCATION OF PROJECT: Various Locations

COGNIZANT HEADQUARTERS OFFICE: Office of the Comptroller

SUMMARY PURPOSE AND SCOPE:

This project provides for minor facility construction at NASA field installations and Government-owned industrial plants engaged in NASA activities. It includes minor facility projects involving the construction of new facilities or additions to existing facilities, each project of which is estimated not to exceed $250,000. Such minor construction is necessary in FY 1980 to improve the usefulness of NASA's physical plant by making it possible to accomplish needed adjustments in the utilization and augmentation of its capabilities.

The $3,500,000 request for FY 1980 is composed of those projects that must be accomplished to meet critical programmatic and institutional requirements in direct support of mission goals and objectives.

PROJECT JUSTIFICATION:

The existing NASA physical plant is impacted by changing utilization and adaptations required by changing technology and mission needs, as well as by new facility requirements generated by research, development, test,

and similar activities. Items included in this project reflect work which must be accomplished in FY 1980 to meet general requirements or technical facilities needs.

This work is required to support specific institutional, research or development programs which could be adequately identified at the time of submission of this budget estimate. Items of work proposed to be accomplished within this program for FY 1980 have been carefully selected from a list totaling about $5 million. This selection has been made on the basis of the relative urgency of each item and the expected return for its accomplishment in relation to the investment involved. It is recognized, however, that during the course of the year some rearrangement of priorities may be necessary and that changes may be required in some of the items to be accomplished within the resources allocated.

PROJECT DESCRIPTION:

Proposed minor construction items for FY 1980 are outlined under "PROJECT COST ESTIMATE" and total $3,500,000. The projects will provide for minor construction of new facilities and additions to existing facilities not in excess of $250,000 per project. These projects represent requirements that must be met in this time frame and will have a direct impact on mission goals and objectives. Their deferral or disapproval could critically affect program schedules associated with approved mission requirements as well as the institutional base which is vital to the operation of the installations.

The FY 1980 request for minor construction work, which is at a reduced level compared to recent prior year amounts, is directed only to the most urgent needs for work of this type in continuation of this essential program at the NASA installations.

PROJECT COST ESTIMATE:

A. Ames Research Center (ARC)	480,000
1. Construction of an Extension to Aircraft Ramp	240,000

This project provides for the extension of the existing aircraft parking ramp Number 2. The new ramp will consist of 4,445 square yards (3,718 square meters) of concrete near the Aircraft Servicing Facility, N-248 and the existing ramp. Included in this project is the extension of the storm drainage system. Additional aircraft parking space is needed to accommodate the increased number of aircraft that are being assigned to ARC. Presently, some thirteen helicopters, research and support aircraft are assigned to ARC. As a result

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of expanding program activities for the Vertical Take-Off and Landing (VTOL) research, an additional eleven aircraft will be assigned to ARC. These additional aircraft will require this ramp space due to the increase of research operations, and to assure safe and efficient aircraft ground operations.

2. Construction of Space Projects Facility..... 240,000

This project provides for the construction of a Space Projects Facility to provide space for conference rooms and general offices. This facility will be a single story concrete building of approximately 4,200 square feet (390 square meters) to be located between the Flight Projects Facility, Building N-244 and the Space Science Research Laboratory, Building N-245. Included in this work will be suitable electrical power, lighting and HVAC systems. This building will alleviate the existing overcrowded, inefficient arrangement of personnel presently in Building N-244 and trailers. This project will allow for the elimination of the two trailers presently used as permanent offices and housing of approximately 20 people. This new facility is necessary to support expanding programs associated with the Space Projects Division and the Reliability and Quality Assurance Office. Such programs as Galileo, Mars Penetrator and Spacelab Infrared Telescope will require additional space for personnel during peak manning periods. Present overcrowded conditions do not allow for the increase in personnel planned as a result of the above programs. This project will provide relief from existing overcrowded conditions and provide for peak office space requirements generated by project programs.

B. Dryden Flight Research Center..... 325,000

1. Construction of Addition to the Aircraft Construction and Modification Hangar, Building 4801..... 185,000

This project provides for the construction of a 2,320-square foot (215 square meter) addition to the east side of Building 4801, which will house the F-15 Aircraft Simulator. The addition will consist of a pre-engineered metal building on a concrete slab, and will be provided with adequate heating, cooling, lighting, fire protection, and electrical power. The existing east wall will be modified to eliminate one column to allow entry of the aircraft. The wall of the addition will be designed in a manner so that the aircraft simulator may be removed. The F-15 program consists of controlling the engine, inlet and flight control systems in an integrated manner using an aircraft-mounted computer. The capability of verifying the correctness of the software prior to flight is fundamental to the program and requires the simulation of major flight elements. It is imperative that the structure, which houses the F-15 simulator, be in proximity to the existing simulators that are located in Building 4801 in order that existing available electric and hydraulic power and data cables may be utilized.

2. Construction of Addition to Central Hydraulic System..... 140,000

This project provides for the addition of the existing Central Hydraulic System to service the Aircraft Construction and Modification Hangar Building 4801. The existing Central Hydraulic System, which was provided for with FY 1978 funding, consists of four modular pump units, a 600-gallon (2.3 kiloliters) central hydraulic reservoir and a hydraulic fluid distribution piping system to the Main Hangar Building 4802. The pump units and reservoir are housed in a soundproof pump house adjacent to Substation No. 1. The system's extension will consist of an additional pumping module housed in the existing hydraulic pump house, high pressure supply and return piping to Building 4801 and four wall-mounted quick disconnects in Building 4801. The present portable units now used to supply hydraulic fluid are old, noisy and difficult to maintain. Due to the age of these units, replacement parts are no longer in stock and it has become necessary to cannibalize some units to keep others in operation. The decreasing reliability and increasing maintenance requirements of these portable units are of major concern. In addition, they are extremely noisy, especially when operated inside a hangar. The noise, which exceeds the acceptable 85 dB level, is such that it interferes with normal speech communications in the hangar. To reduce the noise level, some of the continuous duty units have been enclosed in air conditioned "sheds" which occupy limited hangar floor space. The central system will have increased capability, will eliminate noise hazards, provide increased reliability/flexibility, and will require minimum maintenance.

C. Goddard Space Flight Center (GSFC)..... 550,000

1. Construction of Addition to Instrument Construction and Installation Laboratory, Building 5..... 150,000

This project provides for the construction of an addition to the west wing high bay of the Instrument Construction and Installation Laboratory, Building 5. This addition will be approximately 1,800 square feet (167 square meters) on a concrete slab floor with a 32-foot (9.8 meter) eave height of steel frame and insulated siding to match the existing building. Electrical power, lighting, heating, ventilating, and fire protection systems will be included. The work also includes the installation of a 25-foot (7.6 meter) high roll up door and an electrically operated 5-ton (4,536 kilogram) monorail hoist for the handling of payloads. The Sounding Rocket program is an on-going program with various payloads becoming more complex; and, it is expected to continue for an indefinite period of time. The construction of the addition to Building 5 is required to improve the handling of Sounding Rocket payloads. The present configuration of Building 5 requires the penetration of the Sounding Rocket Integration Area during payload handling with the potential of contamination of the facility. Construction of this addition to Building 5 will provide improved conditions for the handling of Sounding Rocket Payloads, and reduce the potential of contamination of the existing facilities.

2. Construction of S-Band Simulation Operations Center..... 155,000

This project provides for the construction of a S-Band Simulation Operations Center (SOC) near the Network Training and Test Facility, Building 25. This work will include the construction of a concrete foundation to support a 10-foot (3 meter), S-Band Parabolic antenna and a 600-square foot (56 square meter) concrete apron to support an electronic equipment van. Clearing, grading and the construction of an access road of approximately 500 feet (152 meters) to the site will be included. Electrical power, grounding services and signal cables will be extended to the site. The SOC is needed to emulate the Tracking and Data Relay Satellite Systems (TDRSS) user spacecraft to the control centers for the purposes of training, hardware and software checkout. The SOC will also be used to provide an alternative comparative test of the total TDRSS system through to the user by emulating the spacecraft. There are no other complete end-to-end simulation facilities available. The 10-foot S-Band Parabolic antenna and the electronic equipment van are being provided by other means.

3. Construction of Addition to Road No. 1..... 245,000

This project provides for the construction of a two-lane addition to Road No. 1 to the northwest part of the Center. The 22-foot (6.7 meter) wide roadway will extend from the intersection of Road No. 10 approximately 2,200 feet (670 meters) to connect to Road No. 4. The two-lane roadway will include 4-foot (1.2 meter) wide shoulders and be constructed with a 9-inch (22.9 centimeter) asphalt overlay surface. This work will also include the necessary grading, drainage, landscaping, and lighting. The construction of an addition to Road No. 1 is the result of a traffic survey of the existing conditions at the Center. This survey indicated the need for an additional road in the northern part of the Center due to the increased personnel density in Buildings 5, 7, 10, 15, and 28, and to improve the access of emergency vehicles to Buildings 19 and 20. The addition to Road No. 1 is in accordance with the Master Plan and is needed at this time to improve the overall traffic conditions at the Center. Failure to provide this needed roadway addition will continue to increase the traffic congestion at the Center, and require further maintenance to the present road system due to the heavy vehicle loading beyond the planned capacity.

D. Jet Propulsion Laboratory (JPL)..... 1,145,000

1. Construction of Addition to Laser Research Building 149..... 245,000

This project provides for the construction of a 2,960-square foot (2,748.8 square meter) two-story addition to Building 149 to house laser research activities which are now in inadequate facilities. The first floor will be at ground level and the existing 16-foot (4.9 meter) door will be relocated to the east exterior wall of the addition. The addition will contain 1,480 square feet (1,374.9 square meters) of laboratory space on the ground floor and a similar amount of office space on the second floor. The exterior walls of this new addition will be concrete block, and the second floor and roof framing will be light weight steel trusses with steel decks and light weight concrete slabs. An exterior stairway, on the north face of the new addition, will provide access to the second floor. Activities relating to high energy lasers are located in the Laser Group at JPL. This group has pioneered in the development of metal vapor lasers, and has been instrumental in bringing to fruition the copper halide laser, which is currently under intensive study at JPL. Experiments relating to the development of these lasers are currently being carried out in Buildings 107, 134, and 192. The Electric Propulsion Laboratory, Building 192, will not be available to the Laser Group because of the expansion of electrical propulsion work in that building. The Plasmadynamics Laboratory, Building 107, and the Thermonic Assembly Laboratory, Building 134, were constructed in 1945 and 1954 respectively. All major support equipment in Building 107, such as the vacuum pumps, distilled water cooling system and the one megawatt power supply, are over ten years old and require major reconditioning. In addition, Buildings 134 and 107 are scheduled to be demolished. Future laser work will require the construction of large lasers with the attendant safety problems associated with chemically toxic lasants, high voltage power supplies and high intensity laser emission necessitating the use of extensive room partitions, upgrading of the air-conditioning system and new modular designs for safeguarding electrical power supplies. To satisfy these requirements, it is necessary that this increased laboratory space be provided.

2. Construction of Addition to Blockhouse, Building E-22, Edwards Test Station..... 215,000

This project provides for the construction of a 1,050-square foot (98 square meter) addition to Blockhouse, Building E-22, to provide area in this central control building to house the remote control and instrumentation equipment for hazardous test operations. The proposed addition will be constructed of concrete masonary units to match the existing structure.

An entrance, loading dock, service area, darkroom and men's and women's toilets will be provided. A computer floor will also be installed over the total area of the existing floor in Building 22. The added Building area will permit the relocation of the men's toilets and the darkroom to allow for expansion of the computer floor area to accommodate the modernization of the remote controls for D and C stands and the central

recording equipment common to all testing activity. The existing building layout does not allow for the location of necessary tape recorders or remote controls for C and D stands. In order to do this, the existing toilets and darkroom facilities will have to be relocated and an additional area will have to be constructed to provide work area and "office" space. The existing equipment access to the building is poor as there is no way to lift heavy equipment up to the floor level. The existing raised computer floor area is too small, poorly constructed and outdated. A new, modern modular computer floor is required to support the heavier equipment. This addition and modification is necessary in order to allow the building to accommodate the necessary remote controls in a functional and seismically secure installation.

3. Construction of Addition for Fuel Conversion Laboratory, Building 148..... 245,000

This project provides for the construction of three area additions to the existing Conversion Laboratory, Building 148, in support of on-going fuel conversion research programs. These additions consist of a 500-square foot (46.5 square meter) new mezzanine along the west end of the existing high bay, a new 600-square foot (55.7 square meter) second floor over the one-story west wing of the building, and a new 1,200-square foot (111.5 square meter) two-story addition attached to the west of the west wing of the existing structure. The new two-story portion would be a 15-foot by 40-foot addition. The foundations, first floor, columns, beams, and second floor will be poured-in-place concrete. The structural framing above the second floor line, on all additions, will consist of steel framing and metal studs. The 600-square foot (55.2 square meter) new addition on the first floor will be metal louver fillers between the concrete columns. This space will be used for storage and operating of equipment that requires the open space and ventilation that this space will offer. The new 1,200 square feet (92.9 square meters) of space over the existing first floor and the 600-square foot (55.7 square meter) new addition would be used for laboratories and office space. The 500-square foot (46.5 square meter) mezzanine would be developed into a laboratory area. Appropriate heating, ventilating, air conditioning, electrical services, and lighting would be provided.

This facility is currently used to support several NASA fuel research programs including (1) hydrogen generator development for aircraft/automotive applications, (2) vehicle emissions and performance characterization, and (3) fuel processing of alternate fuels for fuel cells. The facility contains seven separate test bays with two control rooms and supporting control and instrumentation. The facility contains one light machine shop and a light fabrication area.

Of the seven test areas in the facility, only two are available for hydrogen generator development and fuels processing. For the past three years, the Fuels Processing Group has averaged three to four separate programs which requires sharing of the two test and fabrication areas. The availability of two additional test areas and one adjacent control area will provide for concurrent test capabilities. The time sharing of the control data acquisition system and gas analysis systems will be continued.

The expensive and non-productive time sharing of test areas will be eliminated. The practice of reconfiguring a test area for support of multiple programs is often more expensive and time-consuming than the actual tests and will be eliminated by the proposed addition. This will provide adequate test and supporting installation and assembly area for the continuing three fuel processing programs with two additional energy programs planned in the catalytic combustion and ultra-rich, partial oxidation area.

4. Construction of Two Illuminator Towers, Building 212..... 245,000

This project provides for the construction of two Illuminator Towers at the Antenna Laboratory, Building 212. The work includes the construction of one 38-foot (11.59-meter) high tower and one 48-foot (14.63-meter) high tower using structural steel on concrete footings.

Work platforms connected by stairs will permit access to all portions of the towers. Platforms will be equipped with kick plates and hand rail stairs, and platform design detail will conform to OSHA requirements. Minimal lighting will be supplied for night work capacity. There are three temporary illuminator towers at the Mesa Range that are used for testing and verifying the accuracy of the antennas used on the spacecraft. These existing towers are constructed of tubular aluminum scaffolding. Vertical members are connected by slip fit and pin stays. Horizontal members and cross bracing are held together by clamps and/or thru-bolts. This type of construction is for temporary scaffolding and not for the rigidity required for the verification of antenna operations. Any wind will cause these towers to oscillate, thus making it difficult, if not impossible, to obtain accurate measurements of the antenna. The existing structures are in violation of OSHA requirements. This project work also includes the demolition of the three existing temporary towers.

5. Construction of Propellant Processing Building, Edwards Test Station (ETS)..... 195,000

This project provides for the construction of a 330-square foot (30.7 square meter) building for oxidizer grinding with double base propellants plus the necessary access road and utilities. The building will be constructed of concrete block and will have a blow-out wall. The building will be insulated and temperature stablized using hot water heating and direct expansion cooling equipment. Necessary safety items, sprinklers and exhaust systems are part of this project. The proposed facility is planned as part of the "batch production" sites for double base propellants at the Edwards Test Station (ETS). These propellants are coming under intensive R&D development and there are being required for retro motors on long-range missions. Facilities need to be made available to safely handle the quantities of fuel involved in the anticipated processing operations. Siting of these facilities will be in accord with safety criteria requirements as shown on the ETS Master Plan.

E. Johnson Space Center (JSC)..... 120,000

1. Construction of Additions to Manned Space Flight Exhibit Complex..... 120,000

This project will provide for the expansion of the Manned Space Flight Exhibit Complex. It will provide restrooms for visitors, a landscaped area for picnics and an astronaut display. The work will include site grading at the Saturn V display area and extending underground storm drain lines to new area inlets. Outdoor lighting will be provided for the entire exhibit complex. The project also will include construction of a masonry restroom facility. Electric heating will be provided, and existing water and sewer lines will be extended to serve the structure. In addition, a landscaped area including sidewalks, benches and tables will be provided. Further, an astronaut display will be constructed, consisting of concrete panels to accept engraved metal plaques and/or sculptures to be otherwise provided. In order that a proper display will be available for suitable public use, adequate drainage at the Saturn V display area and expansion of the facilities of the Manned Space Flight Exhibit Complex will be required. The restrooms are necessary for practical reasons, as well as convenience, since it is the point where visitor tours at the Center begin and end. With these new provisions, the use of restrooms in buildings on the tour route, and the resultant straying of visitors, will be significantly reduced. At present, visitors with picnic lunches eat throughout the JSC grounds. A specifically designated area with landscaping, tables and benches will provide a central, controlled place for this type of activity and thus reduce sanitation and litter problems.

F. Kennedy Space Center (KSC)..... 240,000

1. Construction of Shelter for Oil Atomization Air Compressors, Central Heating Plant, Building M6-595..... 80,000

This project will provide for the construction of a 684-square foot (63.5 square meter) available prefabricated metal shelter at the Central Heating Plant. It will be erected on new foundations and concrete slab. The partially open-sided shelter has dimensions of 18 feet by 38 feet (5.5-meters by 11.6-meters) and is presently in a dismantled condition. Two new compressors for oil atomization will be installed in the shelter The compressors are rated at 235 SCFM at 160 psig each, with 60 horsepower motors. Also included will be 2 new 300-gallon, 200-psig air receivers, with necessary controls, power and piping. The central heating plant boilers burn fuel oil atomized with compressed air. This is presently supplied by a 13-year old reciprocating compressor which was refurbished in 1976, and relocated from Launch Complex 19. However, this system is unable to meet the pressure demand of the boilers. Insufficient air supply or too low a pressure results in poor burning of fuel, black smoke and inefficient boiler operation. This causes the operation of two boilers when one would normally be adequate. The shelter will provide environmental protection for the air compressors and will also provide storage space for existing and future mobile boilers. At present, the

existing air compressor and mobile boilers are located outdoors without shelter, and are subject to accelerated undesirable corrosive effects of the humid local weather.

2. Construction of Automotive Maintenance Facility..... 82,000

This project provides for the construction of a 1,536-square foot (143 square meter) prefabricated metal structure to provide a tire and front-end alignment shop in the GSA Motor Pool. The 32-foot by 48-foot (9.8-meter by 14.6-meter) building will be erected utilizing available steel framework and roof panels from a prefabricated structure which is in storage at KSC. It will be erected on new concrete foundations and floor slab. New metal siding and doors will be provided, and shop air and electrical power will be extended from a nearby building. The present tire shop is capable of handling only a small portion of the required tire inventory, with tire installation being accomplished out-of-doors. Front-end alignment is now performed in a much needed bay in the main shop; however, the equipment will be relocated to this facility. The present operation is extremely inefficient. A savings of one man-year will be realized by consolidation of all related tire functions into a single work area. The project will result in the disposal of three wood-framed office type trailers and three wooden tire storage bins. The existing tire operation is inadequate and this function should be located in a facility with a dedicated alignment bay.

3. Construct Sanitary Sewer Line to LC-39 Press Site..... 78,000

This project provides for the construction of approximately 1,400 feet (427-meters) of 6-inch gravity sanitary sewer line from the Launch Complex 39 press site area to lift station 4E southeast of the Launch Equipment Shop which leads to an existing sewage treatment plant. The existing package sewage treatment plant, which now supports the press site, then will be removed and disposed of. This was a used surplus plant when it was installed at the Press Site in 1966. The plant has deteriorated to a point where it is unreliable and requires frequent maintenance. It is planned to continue use of this area through the Space Shuttle era; therefore, this plant must be replaced to provide adequate sewage disposal facilities in this location. Replacement with a gravity sewer line will be approximately half the cost of a new package plant and will be relatively maintenance free.

G. Langley Research Center (LaRC)..... 415,000

1. Construction of a Personnel Division Building Addition to Building 1195-C..... 240,000

This project will provide for a 5,000-square foot (465 square meter) addition to the Financial Management, Training and Classification Building. This addition will be a simple design using demountable partitions. Exterior finish materials will match existing face brick and window designs in the building. This addition

will contain offices, a conference room and restrooms for the Training and Classification Branches (approximately 25 people) of the Personnel Division. The Classification Branch is presently located in the Library, Building 1194. Because of expanding operations in the library, this Branch must be relocated. The Training Branch is presently housed in Building 1195-X. The existing space is considered substandard. Movement of these branches into Building 1195-C will provide the Division a more cost effective operation by consolidating these organizational units into one functional area.

2. Construction of Addition to the Ceramic Heated Combustion Facility, B-1263..... 175,000

This project provides for an addition of 150 square feet (13.9 square meters) to the test room. In addition, associated equipment such as an air ejector system to allow operation at low static pressures of two to five psi, and a baffle to eliminate ceramic dust are also included. The associated equipment will allow control of the test stream turbulence level. It will also provide a system to inject various contaminate gases into the test stream to allow the study of the effect of contaminate on ignition and combustion. This work is performed in order to evaluate the effects of both turbulence and contaminate on supersonic combustor performance. This facility is unique in that both temperatures and pressures can be achieved simultaneously in a clear atmospheric environment minus the presence of water vapor.

H. Marshall Space Flight Center (MSFC)..... 225,000

1. Addition to the Photographic Laboratory, Building 4353..... 225,000

This project will provide for the construction of a 5,000-square foot (465 square meter) addition to the existing Photographic Laboratory, to replace a 37-year old wing. Upon completion of this project, the existing wing will be demolished. The new addition will be a masonry and steel frame single story structure. It will include an office area, dark rooms, restrooms, storage rooms, and entrance foyer. The existing Photographic Laboratory consists of approximately 21,000 square feet (1,951 square meters) of space of which some 10,000 square feet (930 square meters) were built in 1962, and will be retained for photographic processing. The other 11,000 square feet (1,021 square meters) is obsolete World War II mobilization type construction which has deteriorated to a point that improvement is necessary and replacement with a 5,000-square foot structure (to meet the actual needs) is more economical than to rehabilitate the existing larger structure. This is a wooden structure in which the structural, HVAC and electrical systems have deteriorated through wear and tear, old age and obsolescence. There are no vacant MSFC facilities which are large enough to accommodate

the total photographic function that can be modified at an equivalent cost. Therefore, this construction is needed in the FY 1980 time frame to preclude the necessity of further costly repairs to maintain the existing rundown facility in its present unsatisfactory condition.

TOTAL..... 3,500,000

FUTURE CoF ESTIMATE FUNDING REQUIRED TO COMPLETE THIS PROJECT:

It is estimated that between $3 and $5 million per year will be required for the continuation of this essential minor construction work at NASA field installations and Government-owned industrial plants engaged in NASA activities.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

SUMMARY

FACILITY PLANNING AND DESIGN

	Amount (In dollars)	Page No.
Regular Requirements:	9,850,000	
Master planning	300,000	CF 15-2
Sustaining engineering support	1,750,000	CF 15-3
Preliminary engineering reports and related special engineering support	2,500,000	CF 15-6
Final design	5,300,000	CF 15-7
Other Requirements:	4,150,000	
Shuttle facility planning and design	700,000	CF 15-7
Spacelab/payloads facility planning and design	300,000	CF 15-8
Energy reduction analysis and support	1,150,000	CF 15-8
Numerical aerodynamic simulation facility planning and design	2,000,000	CF 15-10
Total	14,000,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1980 ESTIMATES

PROJECT TITLE: Facility Planning and Design	
	FY 1980 CoF ESTIMATE: $14,000,000
FY 1978: $11,780,000	FY 1979: $10,650,000

The funds requested in this estimate are required to provide for the following advance planning and design activities related to facilities activities and projects.

a. The accomplishment of necessary development and master planning for field installations and, where not otherwise provided for, the provision of continuing engineering support and special engineering management and other services.

b. The preparation of preliminary engineering reports, cost estimates, and design and construction schedules.

c. The preparation of final construction plans, specifications, and associated cost estimates and schedules that are required to implement construction projects.

d. The accomplishment of facilities siting and other investigations, as well as the accomplishment of special facilities studies and reports.

This request for facility planning and design resources for FY 1980 is composed of two major segments:

a. Regular requirements - $9,850,000
b. Other requirements - $4,150,000
Total $14,000,000

Regular requirements encompass the basic purposes outlined above. The "other requirements", while also in support of these purposes, cover those special needs which are related to large, complex projects or specific programs which are considered to represent high potential future construction requirements and for which early definition is essential. The large projects require significantly more planning and longer lead time than is normally involved. Much of this planning must be completed prior to inclusion of the project in a budget request.

1. REGULAR REQUIREMENTS..... 9,850,000

A. Master Planning..... 300,000

This portion of the requirements provides for the updating and further development of existing master plans for the field installations, including facility studies and site investigations. Documentation will define facility parameters within which subsequent engineering efforts will be based for future development. This also provides for the documentation of existing plans where actions or deviations from previous plans have not been recorded for the various field installations.

Master plans at the various field installations are generally updated at cyclic 3-year intervals. Approximately one-third of the field installations are involved in any one fiscal year, keeping the level of effort relatively modest and constant. These plans provide for the orderly consideration of the allocation, proper arrangement, and efficient correlation of land areas and structures to serve the purpose of the various installations. Representative master planning activity candidates for FY 1980 are:

(1) Ames Research Center

This will be a major update to define latest NASA/adjacent community planning and utilization interfaces, 40x80-Foot Wind Tunnel expansion needs and impacts, and other land planning factors. It will include off-site activities, updating of the 5-Year Plan data and definition of tenant facility needs and uses, especially those associated with occupancy by the US Army.

(2) Jet Propulsion Laboratory

This envisions only a minor update to show latest utilization as impacted by Department of Energy's energy programs, leased space holdings and use in graphic form, and an update of master planning data.

(3) Kennedy Space Center

This will be a normal inventory update to include new Shuttle and Payload facilities, to incorporate the utilization planning for those Cape Canaveral Air Force Systems facilities NASA will require as the Shuttle moves into the operational phase.

B. Sustaining Engineering Support..... 1,750,000

Provisions for facility studies and specific engineering support continue to take on an added importance which has been evidenced in recent years, and must be given further high priority throughout FY 1980. These efforts are of utmost importance due to the more unpredictable cost situation which currently exists and may continue; cost trends in construction materials and fuels; the continuing importance of energy conservation and efficiency; and the operation and maintenance cost for the physical plant. This also includes provisions for maintaining a current engineering data base and updated construction specifications for utilization by the various field installations.

The following items are included in the FY 1980 requirements:

(1) Building Research Advisory Board Support

This covers annual support to the Federal Construction Council's (FCC) operations and provides special studies that the Council will perform throughout FY 1980 to help advance the science and technology of Federal Government building and construction. The FCC is a committee of the Building Research Advisory Board, National Academy of Sciences, and its activities are supported by several Federal Agencies including NASA.

(2) Utilities Services/Rates Analysis

This provides for continuous services in support of utilities and utility systems which include technical counseling, surveillance and recommendations with regard to utility rates, contract negotiations, systems, operations and control. These services are an annual requirement and will continue in importance as long as energy costs continue to escalate.

During FY 1978 these resources have enabled the Agency to properly realize fair and reasonable rates that are offered to our field installations by utility companies. Several major utility contract negotiations have received very valuable technical assistance from the expertise that these resources provided. At Ames Research Center (ARC) and Langley Research Center (LaRC), major electric utility contract negotiations

are presently underway, and it is anticipated that one or two major utility contracts per year will require expert technical input as utility contract renewals move through a normal cycle throughout the Agency.

Also, these resources provided for an initial study to more accurately forecast utility costs and rates so that better and more reliable utility budget requirements can be established. Resources will be required to continually update these projections twice each year in order to maintain a high level of credibility and use.

Another significant use of these services is the establishment and implementation of NASA's utility control and management system which will require close coordination and technical input during the several years of its installation and checkout as a functioning system.

These and other similar utility system services are provided for by these resources in order to properly manage this function.

(3) Design Specifications Update and Support

This provides for the continuation of engineering services for the updating and refining of the Agency-wide construction specification system. This system combines a catalog of preapproved standard construction specifications, and a cost effective program for selective retrieval and printout of bid specifications. These standardized specifications are used by Architect-Engineer firms to produce bid documentation which is uniform throughout the Agency and easily updated.

(4) Facility Operation and Maintenance Analysis

This provides for continued engineering support in implementing improvements at the NASA field installations relative to manpower utilization, work control systems, preventive maintenance, facilities management and reporting systems. The improvements will also involve techniques that will be used to identify where and how increases in productivity may be possible by the use of earlier but still reliable measurement methods. Also included in this activity will be some field surveys to be conducted on a priority basis at selected NASA field installations to evaluate the effectiveness of the operations and maintenance management systems.

(5) Value Engineering Cost Validations and Analysis

This will provide for engineering services to improve, whenever possible, cost effectiveness of facility projects by subjecting project design criteria, specifications and working drawings for specific material components and systems to a detailed independent review by engineering specialists in the particular area of involvement. It will also provide services necessary to more accurately predict and validate facility costs which will aid in resources planning for the various field installations.

(6) Facilities Utilization Analyses

Provides for the analysis of Agency-wide facilities utilization data covering: (1) office and other types of building space; (2) utilization data on designated major technical facilities, and (3) special utilization studies of comparable technical facilities such as wind tunnels. This analysis provides for the review of data assembled in various formats, thereby permitting: (1) insights into, and development of, better methods of identifying underutilized facilities; (2) improved techniques of quantifying their level of use; and (3) actions for improved utilization. This work also provides for special reviews of each installation's inventory data base in support of the facilities utilization program. These surveys are necessary to validate the reported data especially in relation to a specific problem or need, and thus assist in the provision of a credible foundation for plans to further improve the utilization of facilities.

(7) Environmental Studies

This provides for the identification of potential environmental problems or the quick resolution of any controversies that may arise at any of the NASA field installations. These conditions may be brought about by:

- New Federal, State and Local environmental regulations, emission standards and environmental management planning programs that must be considered at various installations.

- Changes that may take place at some NASA installations resulting from new or expanded program activities, new facilities, or major changes in site expansions.

- Changes that take place in the external environmental conditions around the installations.

The early identification of any potential environmental problems and quick resolution of these and related controversies at the installations are important. Project Managers and Facility Planners require

up-to-date and accurate information to ensure compliance with all legal and regulatory requirements which are rapidly becoming most imposing and complex.

C. Preliminary Engineering Reports and Related Special Engineering Support..... 2,500,000

(1) Preliminary Engineering Reports (PER's)..... (1,800,000)

Preparation of PER's, investigations, and project studies related to proposed facility projects to be included in the FY 1982 and FY 1983 Construction of Facilities programs are provided for by this estimate. These reports are required to permit the early and timely development of the best project required to meet the stated functional need and to provide the related basic data, cost estimates and schedules related to any such future budgetary proposals. This request will provide for PER work associated with proposed subsequent construction except as provided for in "Other Requirements" (Paragraph 2) for Space Shuttle, Spacelab/Payload, and the Numerical Aerodynamic Simulation Facility. For the FY 1982 program, PER work associated with an estimated cost of $25 million of construction for which updated PER's will be needed, and with new projects estimated to cost approximately $45 million for which complete new PER's will be required. The estimated cost for the FY 1982 PER effort is $1,100,000.

An additional $700,000 has been included in this line for the completion of new PER's for approximately $35 million of construction projects which will be high priority candidates for inclusion in the FY 1983 Construction of Facilities program. The activity associated with FY 1983, which will be confined to the most urgent and clear-cut priority candidates, is being undertaken on a limited basis in an attempt to obtain earlier and better definition of programs. It is felt that this will permit better budget estimates, earlier design completion, and thereby result in better and less costly projects. If proven successful, we plan to increase the early detailed review of such candidate projects in future years. This is made essential by the extensive lead time now associated with PER work and the more limited Center capabilities to manage such work on a compressed schedule as we have done in the past.

(2) Related Special Engineering Support..... (700,000)

Investigations and project studies related to proposed facility projects to be included in the subsequent Construction of Facilities programs are provided for by this estimate. Such studies have taken on an increased importance in recent years and involve documentation and validation of "as built" conditions, survey/study of present condition of such items as roofing and cooling towers, utility plant condition and operational modes, analysis and support of environmental impact assessments and statements and other like studies. These studies are required to allow for the timely development of projects to meet the stated functional needs and to provide basic data, cost estimates, and schedules for related future budgetary proposals.

D. Final Design..... 5,300,000

The amount requested will provide for the preparation of designs, plans, drawings, and specifications necessary for the accomplishment of projects other than Space Shuttle, Spacelab, Payloads, and the Numerical Aerodynamic Simulation Facility. Amounts required for these efforts are included under "Other Requirements" (Paragraph 2). Projects involved are planned for inclusion in the FY 1981 and FY 1982 programs. In prior submissions, amounts were principally for BY +1. In this submission, early final design for selected high potential BY +2 projects is proposed. This is in accord with the overall plan discussed earlier in the Preliminary Engineering Report estimated to obtain better facilities on line earlier at a lower cost.

The request will provide for final design work associated with construction proposed for the FY 1981 Program, estimated to cost $75 to $80 million, and for $12 to $15 million of high potential projects proposed for the FY 1982 program. The amount included for FY 1981 candidates and for residual requirements of this nature which have accumulated from prior years' final design activities is $4,500,000. For FY 1982, $800,000 is included and the supporting rationale is much the same as that set out in the PER estimate.

2. OTHER REQUIREMENTS..... 4,150,000

These other facilities planning and design requirements are generated by potential future projects, large in size and of a complex nature. Those in this particular request are primarily associated with future space programs which require a long planning cycle. Early and progressive design work is essential to ensure the ultimate best design, cost estimates and schedules. These projects then require planning effort and associated design lead time well beyond that normally associated with preliminary engineering reports and general type facility projects. For this reason, these requirements must be provided for beyond the regular and most recurrent facility planning and design needs covered show.

A. Shuttle Facility Planning and Design..... 700,000

(1) Shuttle Facilities Final Design..... (330,000)

This portion of total facility planning and design required for Space Shuttle is associated with the preparation of final design drawings and specifications required for future construction of Space Shuttle facilities, which in FY 1981 are estimated to cost approximately $33 to $36 million. As in the FY 1979 budget request, design costs are lower than previous years due to the fact that some projects are later phases of earlier projects, and the complete facility was designed at one time with resources requested only as needed to support program milestones. The design effort is mainly related to the operational phase of the Space Shuttle program at Kennedy Space Center and Michoud Assembly Facility. Projects forecasted for FY 1981 may

include a third mobile launcher (MLP-3), logistic facilities, and addition to thermal protection system (TPS) cells.

(2) Space Transportation System (STS) Studies and Preliminary Design..... (370,000)

This requirement is associated with the preparation of PER's, the conduct of facilities investigation, and studies for facilities projects which, in most cases, will be included in the FY 1982 Construction of Facilities program. This preliminary work is associated with future construction for that year now estimated to cost approximately $18 to $23 million. Additionally, studies and PER's will be undertaken to examine the facilities needed to enhance the operational phase of the STS. These facilities relate to solid rocket motor storage, external tank (ET) production at increased levels and shops and logistics facilities. PER's in the amount of $250,000 will be required to suppport decisions relating to out-year requirements. In addition, studies estimated at $120,000 will be required in order to provide quick response, cost analysis and trade-off studies of potentially feasible projects.

B. Spacelab/Payloads Facility Planning and Design..... 300,000

As the Space Shuttle Transportation System moves into its operational phase, additional facilities will be required to provide the capability to develop, integrate, and check out scientific, application, and upper stage payloads. This planning requirement relates to the previously mentioned payload requirements. Projects forecasted for FY 1981 include a Level IV Payload Integration Facility,and a Multimission Support Equipment Maintenance Facility. In addition, a PER for a Payload Processing Facility at Vandenberg Air Force Base is forecast.

C. Energy Reduction Analysis and Support..... 1,150,000

This is a continuation into the second phase of the requirements for energy reduction analysis and support in response to several factors: (1) the increased need and urgency to conserve energy as an essential element of good business and economic viability; (2) the continuing focus and emphasis accorded to energy reduction in building and facilities as an outgrowth of the requirements of Executive Order No. 12003; and (3) the continuing growth of these requirements as reduction efforts continue to expand. This FP&D requirement thus covers those special needs which are frequently related to complex facility studies, analyses, and other preliminary activities leading to the better identification of highly probable cost and energy effective facility projects. These preliminary activities are vital to the total effort of future energy reduction and must be undertaken on a priority basis if long-term energy reduction goals are to be attained.

NASA has continuously intensified its efforts to identify, study and develop new energy reduction

initiatives which could most probably result in sound and effective facility projects. In turn, it is anticipated that these resultant projects will reduce and/or limit future energy consumption through improved efficiency and, at the same time, minimize the impact of rapidly rising energy costs. Experience to date continues to demonstrate that these planning resources can produce appreciable energy reductions and can direct investment resources toward the most prudent and cost effective modifications to facilities on some priority basis. As compared to FY 1977 usage, for example, during the first three quarters of FY 1978 approximately $4,200,000 in additional energy costs were avoided during just nine months through the increased effectiveness of energy management and by modest prior investments. An anticipated additional 10 to 15% reduction in NASA's total energy consumption can probably still be achieved through additional planning, resulting in an estimated additional utility cost savings of between $8-12 million per year in terms of average FY.1978 energy costs. These resources for needed anticipated planning are therefore essential since they are the key to the timely identity of the future facility investments. If this identification effort is not accomplished in a timely manner, millions of dollars of additional downstream utility and other costs will be reflected. These resources will be used for the following major areas of effort:

(1) To provide for the second phase of an anticipated multiphase program over the next three years to support and comply with the intent and directed purpose of Federal Executive Order No. 12003. This Executive Order places focus and emphasis on saving energy in existing buildings. NASA has approximately 2,500 buildings with a total of over 30,000,000 gross square feet of floor area. Of these, there are 226 which contain over 30,000 gross square feet each. This analysis and study effort will continue to provide the necessary "energy audits", engineering services, economic evaluations, and other technical support necessary to initiate the evaluation of these "energy intensive" major buildings and/or central utility plants.

To date, NASA has completed several major energy audits/appraisals of its buildings and facilities. Approximately three major energy components have been reviewed, with an additional 7-8 more NASA Centers yet to be initiated. In addition, a major study effort has been initiated to develop a methodology whereby detailed energy study efforts can be applied in a prudent manner. This new and innovative methodology hopefully will enable NASA to quickly and inexpensively identify its most energy wasteful buildings so that more detailed and costly study efforts can be selectively applied.

The emphasis of this effort will also continue the determination of actual system configuration and thus operational modes and subsequent study alternatives. The heating, ventilating, and air-conditioning systems, lighting, thermal and electrical distribution systems, and any other operations, systems, or functions which require energy utilization/reduction analyses and evaluation will continue to be involved. The present program plan is to develop an intensive three-year investment program that will include all essential and cost effective energy conserving measures in all NASA buildings.

Previous experience and results have indicated that very productive energy conservation initiatives associated with buildings can be identified and that these do result in significant energy savings with normally less than five years but not more than eight years "simple payback". Specifically, these initiatives include control modifications, electrical power reductions, and system optimizations.

(2) To provide for engineering support, studies, and analyses involving changes in criteria and design methodologies, operation and maintenance procedures, improved research testing procedures, facility energy impacts due to new programs as well as cost and energy effective evaluations of investments. Other technical energy investigation and identification efforts, including fuel conversion and application of nondepleting resources associated with NASA's technical/operational facilities are essentially complete. These resources are to provide for some residual efforts and the completion of these studies already underway.

D. Numerical Aerodynamic Simulation Facility Planning and Design..... 2,000,000

These planning and design resources are the first increment of the approximately $6,500,000 required to provide preliminary evaluation and design, preliminary engineering, and final design for construction of a facility (building, equipment and system software) dedicated to the numerical simulation of aircraft aerodynamics and other fluid dynamics applications. This request will provide for engineering support for validation studies, user interface design, preliminary engineering, specifications development, and final design. The cost of construction of the proposed Numerical Aerodynamic Simulation Facility (NASF) at Ames Research Center, Moffett Field, California, is currently estimated to be between $75,000,000 and $90,000,000. This planning and design effort is not intended in any way to reflect a final decision to construct this facility. Rather, it is directed toward developing planning and design information which can then be the basis for decisions on construction during future budget formulations.

Historically, the design of aerospace vehicles has relied heavily on fluid flow simulations to identify and verify aerodynamic characteristics. At present, these simulations are obtained at great expense in time, energy, and other resources primarily by using scale models in ground-based experimental facilities, such as wind tunnels. The performance of new aerospace vehicles is often compromised by over-design because of test facility limitations. Some of the inherent limitations of these simulations are model size, wall and support interference, aeroelastic distortions and large energy requirements. Many of these limitations can be overcome by solving well-known mathematical equations governing fluid flow using modern numerical calculation methods. This is defined as "numerical simulation" and is in contrast to the ground-based scale model simulation referred to above. The proposed facility will also be capable of providing a significant increase in processing power for a broader scope of related applications such as weather and climate modeling that are based on the same fundamental fluid dynamic equations and numerical solution techniques.

Design validation will provide technical information in the early stages of project development to assure the government best state-of-the-art design. Included in this effort will be: (a) evaluation of preliminary designs, including simulation to verify function and performance estimates; (b) refinement of performance measuring criteria; (c) identification and prototype checkout of critical system components; and (d) assessment of system reliability, availability and serviceability.

The integrated facility design will provide a component description of the total system. This will lead to the identification of hardware and software components. Additionally, it will lead to preparation of the physical requirements of the system in sufficient detail to provide design criteria for the construction of a building to house the system.

User interface design will include programming language development, and subsystem integration involving such items as data security, graphics support, flow simulation model preparation and result analysis, and machine scheduling systems.

Due to the extent and complexity of this project, construction management services will start with the early planning required for smooth implementation of this project. Elements of this planning will include development of a detailed management plan and complementing management systems for total facility construction and system integration; coordination of system engineering and building design activities; and specification of operational procedures for the successive stages of system implementation throughout the construction phase.

Final system design and engineering performed in parallel by at least two competing contractors can begin in 1980 and extend into 1981. The preliminary engineering includes design validation, integrated facility design, and user interface design, cost and schedule. These system design and engineering efforts will provide system architecture, detailed logic design and hardware specification, and critical component prototyping and simulation. At the conclusion of these efforts, and subject to appropriate reviews and approvals, NASA will be prepared to proceed with fabrication and installation of this facility with a management structure and the system specifications necessary to award a construction contract. It also should be noted that by carrying two or more contractors through planning and design phases of project implementation, NASA will be in a position to select, from competing design proposals, the option most beneficial to the government for the contemplated construction phase.

The plan to acquire a numerical aerodynamic simulation facility involves three key steps with built-in decision points which allows NASA to proceed with high confidence at each step. The first decision will be made at the conclusion of feasibility and validation studies relative to initiating system design and engineering. At the present time, with all information from these nearly completed study efforts being favorable to proceeding with the project, it is NASA's intention to continue to the second step, partially financed by

this budget request. The second decision point relates to the review and evaluation of preliminary design results and the desirability of continuing with the program. The third, occurring tentatively in mid-1981, involves the decision to invite construction contract bids with the intention of awarding a construction contract by late 1981. On this basis, the numerical aerodynamic simulation facility is expected to be ready for fabrication and construction in late 1981 with operational status to be achieved in early to mid-1985. This overall approach assures that only the necessary resources will be committed at each step and thus meet the requirements to successfully complete and implement this project.

As covered above, the implementation of this proposed facility will include the design, engineering, fabrication, assembly and testing of computer hardware and software components of a unique processing system, and the design and construction of a building to house the system and support personnel at Ames Research Center (Figure 1).

A major component of the facility will be a specially constructed Flow Model Processor (FMP), designed to solve the three-dimensional equations of fluid dynamics, including viscous effects, that have been cast in the form of numerical flow models. The FMP (Figure 2) will consist of the high speed processor ensemble, the problem data memory, the staging memory and the FMP control, fabricated from advanced, high speed integrated circuit technology components. By organizing these components in a parallel fashion to permit the simultaneous calculation of several results, the FMP will solve the viscous flow equations at a rate possibly as much as one billion arithmetic operations per second for flow fields described by up to one million discrete points. Numerical flow models will be mapped into the FMP through a programming language that clearly and easily describes the models and at the same time allows optimum use of FMP processor capabilities.

Another major component of the facility is the Support Processor System (SPS), taking advantage of standard off-the-shelf processing, storage, communication display, and peripheral devices, designed to directly support the processing of numerical flow models in the FMP. The SPS (Figure 2) will provide scheduling and data transport control for FMP jobs and provide the user interface. Major processing support capabilities include: (1) flow model set-up to prepare and interpret detailed flow model descriptions, including specification of numerical algorithms, boundary conditions, turbulence model and various other flow parameters; (2) configuration geometry/grid generation to prepare the numerical description of test configurations and flow model grid systems, including the preparation of graphical displays and interactive user communications for rapid checkout and modification; and (3) aerodynamic data reduction/display to produce graphic displays of selected aerodynamic information including forces, moments, detailed surface and flow pressures, velocities, skin friction, heat transfer and other flow parameters of interest.

The SPS will control the flow of information to and from the FMP and other ancillary processing and data display devices. It will also provide both short and long-term memory storage for aerodynamic flow models

and data. Researchers will gain access to the FMP and support capabilities through a user interface with data communications links to both on- and off-site locations. This access will be interactive and will be managed by operating system software that allows the time sharing of SPS resources among the users.

The third and final major component of the facility is the building in which the numerical aerodynamic simulation facility equipment and personnel will be located. This building (Figure 3) will be specially designed to properly house the FMP, the SPS and other associated fixed equipment. It is presently estimated to consist of approximately 4,831 square meters (52,000 square feet) and will also include space for operating and research personnel.

As previously indicated, this request is part of an overall requirement of approximately $6,500,000 for this planning and design effort. The $2,000,000 requested in FY 1980 will fund all preliminary evaluation and design, and the start of final detailed design. It is presently planned to request in FY 1981 the remainder needed to complete planning and design.

TOTAL..... 14,000,000

AMES RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES

CONSTRUCTION OF

NUMERICAL AERODYNAMIC SIMULATION FACILITY

LOCATION PLAN

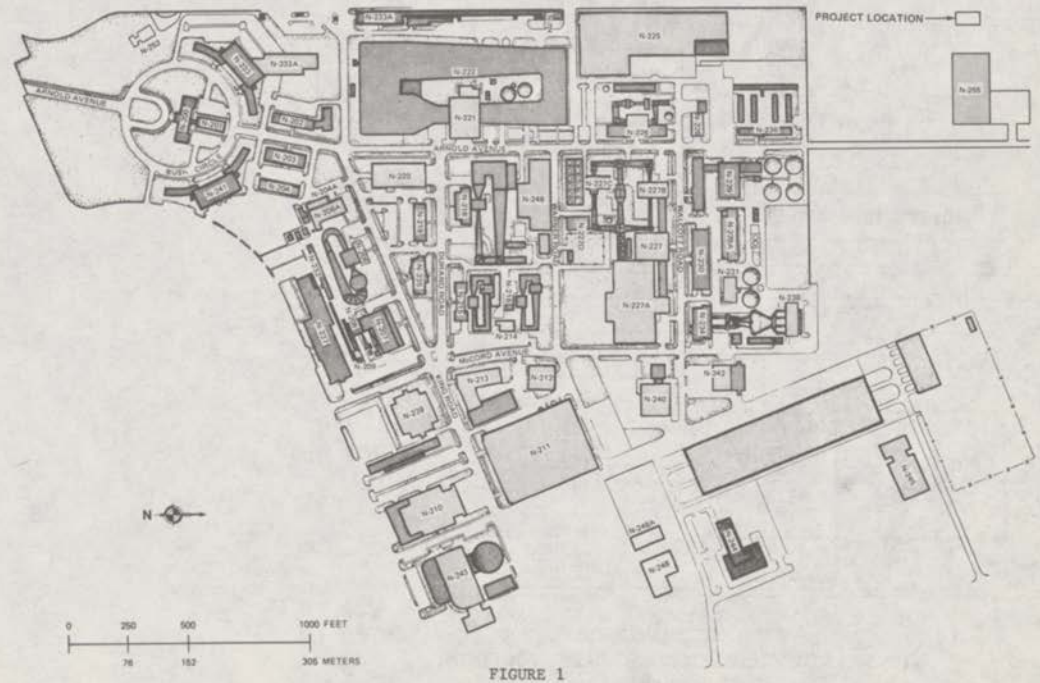


FIGURE 1

CF 15-14

AMES RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES

CONSTRUCTION OF
NUMERICAL AERODYNAMIC SIMULATION FACILITY
SCHEMATIC DIAGRAM

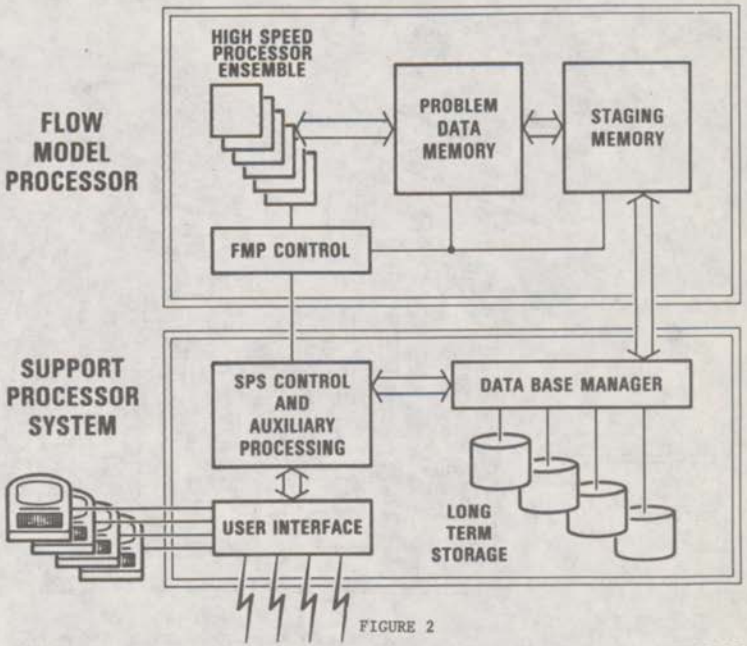


FIGURE 2

CF 15-15

AMES RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES

CONSTRUCTION OF
NUMERICAL AERODYNAMIC SIMULATION FACILITY
FLOOR PLANS



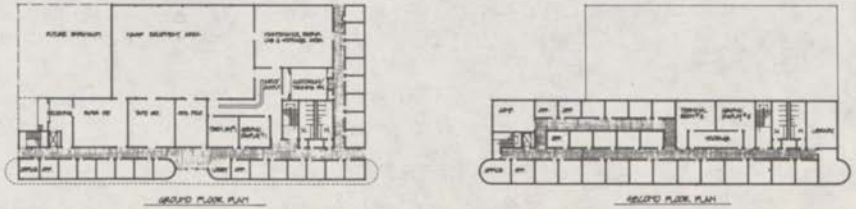


FIGURE 3

CF 15-16

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES

RESEARCH AND PROGRAM MANAGEMENT

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RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1980 ESTIMATES

GENERAL STATEMENT

The Research and Program Management appropriation funds the performance of research, technology and test activities at NASA Centers, and the planning, management and support of contractor research and development activities necessary to meet the Nation's objectives in space and aeronautics research. The objectives of activities funded under Research and Program Management are to (1) to provide the technical and management capability of the civil service staff needed to conduct the full range of programs for which NASA is responsible, (2) to maintain facilities and laboratories in a state of operational capability and to manage their use in support of research and development programs and (3) to provide effective and efficient technical and administrative support for the research and development programs.

The more than 22,000 civil service personnel funded by the Research and Program Management appropriation represent NASA's most important resource and are the strength on which the future of space and aeronautics research activities depend. Three-fourths of this appropriation is required to cover their salaries and related costs. About two percent of the appropriation is for the travel which is vital to successfully manage the Agency's research and development programs. The remaining twenty-three percent provides for research, test and operational facility support and for related goods and services necessary to successfully operate the NASA Centers and to efficiently accomplish NASA's approved missions.

Each installation is assigned certain principal roles of fundamental importance in meeting NASA's overall program goals. These roles reflect the intrinsic competence of the installations on the basis of demonstrated capabilities and capacities. They are summarized as follows:

Ames Research Center: Principal roles include short haul aircraft and rotorcraft systems technology, computational fluid dynamics, planetary probes, and life sciences.

Dryden Flight Research Center: Principal roles include aeronautical flight testing, research and operations, as well as providing a contigency recovery landing site for Space Shuttle flights.

Goddard Space Flight Center: Principal roles include the development and operation of earth orbital flight experiments and automated spacecraft to conduct scientific investigations and demonstrate practical applications; and the management of the tracking and data acquisition activities for earth orbital missions; and management of the Delta launch vehicle.

Johnson Space Center: Principal roles include management of the integrated Space Shuttle program and of the Orbiter development project; astronaut training; mission planning, operation and control; and application of remote sensing to agricultural assessments and other earth resources uses.

Kennedy Space Center: Principal roles are the launch of payloads on expendable launch vehicles, the launch of Space Shuttle operational test flights, and preparation for launch of Shuttle operational missions.

Langley Research Center: Principal roles include long haul aircraft systems technology emphasizing fuel conservation, safety and environmental effects; aerospace structures technology; environmental quality monitoring by remote sensing; and advanced space systems technology.

Lewis Research Center: Principal roles include aeronautical propulsion technology; space and terrestrial energy systems; and management of the Centaur expendable launch vehicle.

Marshall Space Flight Center: Principal roles include management of the Space Shuttle main engine, solid rocket booster and external tank projects; management of NASA's development activities on the Spacelab and Inertial Upper Stage; management of large automated spacecraft projects such as the Space Telescope and High Energy Astronomy Observatory; experiments in materials processing in space; and solar heating and cooling.

The National Space Technology Laboratories: Principal roles are support of Space Shuttle engine development and testing; regional earth resources research and technology transfer; and support functions for other Government agencies located there.

Wallops Flight Center: Principal roles include management and launch of sounding rockets and balloons; and operation of an instrumented flight range.

The 1980 budget provides the necessary resources to apply these inhouse capabilities to the appropriate program activities. A summary description of, and the funding required for each functional category, are as follows:

1. Personnel and Related Costs includes salaries and benefits for NASA civil service personnel, and for personnel of other Government agencies detailed to NASA. This category also includes supporting personnel costs, such as moving expenses (excluding travel of personnel), recruiting and personnel investigation services provided by the Office of Personnel Management, and personnel training.

2. Travel includes the cost of transportation, per diem, and other associated expenses required for the direction, coordination, and management of program activities for both research and development and construction of facilities; for contract management; for flight mission support; for travel to overseas development, launch and tracking sites; for travel to meetings and technical seminars; and for all local and relocation travel expenses.

3. Facilities Services includes rental of real property, the cost of maintenance and related services, engineering, custodial services, minor modifications and utilities services.

4. Technical Services includes the cost of general purpose automatic data processing, the dissemination of scientific and technical information derived from the research and development programs, as well as shop and other technical services.

5. Management and Operations Support includes the cost of administrative communications, printing and reproduction, administrative supplies, general purpose materials and equipment, transportation (excluding travel of personnel), medical services and other support services.

Summary of the Budget Plan by Function

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Personnel and Related Costs	677,450	695,093	720,924	727,176
Travel	17,042	18,741	18,573	19,797
Facilities Services	91,965	102,841	100,757	113,190
Technical Services	40,435	40,357	39,723	42,288
Management and Operations Support	62,614	56,968	61,492	62,449
Total	889,506	914,000	941,469	964,900

SUMMARY OF CHANGES FROM 1979 BUDGET ESTIMATE TO 1979 CURRENT ESTIMATE

The changes that have occurred in NASA's R&PM plans in the past year can be summarized as follows:

1. A net increase of $27,469,000 reflecting the reduction in the appropriation request of $3,500,000 as a result of Congressional action, offset by a request for supplemental appropriations of $30,969,000 to cover the cost of unbudgeted pay raises. The supplemental is part of the President's Government-wide request, and covers the October 1978 general wage increase, and the various Center's wage board increases. The gross amount of these increases in 1979 amounts to $35,080,000. Because of savings effected as a result of the President's freeze on hiring and the directed reduction in staffing of more than 400 permanent positions below the 1979 budget estimate, NASA is able to absorb $4,111,000 of the cost within the existing appropriation. Therefore, the supplemental request is for $30,969,000.

2. The net effect of many management actions to provide for, and offset, higher than anticipated increases in utility rates and in the wage rates in our support service contracts.

The current estimate for 1979, including the proposed supplemental appropriation of $30,969,000, is $941,469,000.

BASIS OF THE 1980 ESTIMATE

The budget estimate for 1980 of $964,900,000, an increase of $23,431,000 over the current 1979 requirement, provides for the personnel and related costs of 22,563 full-time permanent civil service people (a further reduction of 268 from the revised 1979 level), the full year effect of currently negotiated rate increases in support service contracts; increased utility rates; and increased costs of supplies, materials, and equipment, which continue to rise faster than conservation efforts can offset. The 1980 R&PM request, by functional category, is summarized as follows:

1. Personnel and Related Costs are $727,176,000 for 1980. This represents an increase of $6,252,000 over 1979; and is the net effect of (1) the full year savings of the 1979 staffing reduction, (2) the partial year savings of the 1980 decrement in personnel, (3) the net of within-grade advances, career development, and turn-over savings, and (4) the cost of two extra paid days in 1980. The latter is caused by a combination of 1980 being a leap year and the number of weekends included that result in an increase of two paid days over the normal 260 days in 1979 to 262 days in 1980. The cost of these two extra days is estimated to be $4,966,000.

43-843 O - 79 - 52

2. Travel costs in 1980 will be $19,797,000, an increase of $1,224,000 over the 1979 estimate. The travel of civil service personnel to contractor plants, launch and tracking sites, technical meetings and seminars for the accomplishment and coordination of technical and administrative matters is an essential element in the success of the Nation's aeronautics and space programs. The increase planned in 1980 is required to meet 1980 program milestones.

3. Facilities Services are estimated to cost $113,190,000, which is $12,433,000 above the 1979 requirement. This increase is the net result of the full year effect of contract wage rates, utility rates, and supplies, materials and equipment price level increases; and the increase in the level of contractor manpower levels at the Kennedy Space Center in support of the Space Transportation System operations.

4. Technical Services are estimated at $42,288,000 for 1980. The increase of $2,565,000 over the 1979 estimate results from the full year cost of increases in the price levels for the goods and services required.

5. Management and Operations Support is estimated at $62,449,000 in 1980. This is an increase of $957,000 over the estimated 1979 amount, and results from the full year effect of price increases for communications, printing and other installation common services.

The content of each functional category is explained in greater detail in the following descriptions, and the specific requirements for each installation are covered in their respective sections in this volume.

PERSONNEL AND RELATED COSTS

A. COMPENSATION AND BENEFITS:

1. Compensation:

a. Permanent Positions: This part of Personnel and Related Costs covers the salaries of the full-time permanent civil service workforce, and is the largest portion of Personnel and Related Costs. In 1980 the funds will support an end-year employment level of 22,563 people. That level represents a reduction of almost 700 from the 1979 level presented last year, and a reduction of over 12,500 from the peak employment level reached in fiscal year 1968.

b. Nonpermanent: This category includes the salaries of NASA's other than full-time permanent personnel. Programs, such as the students participating in cooperative training, summer employment, youth opportunity, and temporary clerical support, are covered in this category. Also included is the NASA Part-time Permanent Seed Program which was established in October 1978 to encourage the employment of persons who are not able to work full time. This program is in response to a Government-wide policy and the need to experiment with several approaches before committing to specific programs.

c. Reimbursable Detailees: In accordance with existing agreements, NASA reimburses the parent Federal organization for the salaries and related costs of persons detailed to NASA.

d. Overtime and Other Compensation: Overtime, holiday, post and night differential, and hazardous duty pay are included in this category.

2. Benefits: In addition to compensation, NASA makes an employer's contribution to personnel benefits as authorized and required by law. These benefits include contributions to the Civil Service Retirement Fund, employees' life and health insurance, and social security contributions for nonpermanent personnel. The incentive awards provide cash awards for outstanding achievement by NASA employees, superior performance awards, and for improvements of a Center's operations. Payments for severance pay are made to former employees involuntarily separated through no fault of their own.

B. SUPPORTING COSTS:

1. Transfer of Personnel:

Relocation costs, such as the expenses of selling and buying a home, and the movement and storage of household goods are provided under this category.

2. Office of Personnel Management Services:

The Office of Personnel Management is reimbursed for security investigations on new hires, for recruitment advertising, career-maturity surveys, and any requested investigation of formal discrimination complaints.

3. Personnel Training:

Training is provided within the framework of the Government Employees Training Act of 1958. Part of the training costs consist of courses offered by other Government agencies, and the remainder provides for training through nongovernment sources.

TRAVEL

A. Program Travel:

The largest part of travel is for direction, coordination and management of program activities. The complexity of the programs involved and the geographical distribution of NASA Centers and contractors and subcontractors throughout the entire United States impose the requirement for this category of travel. As projects reach the flight stage, support is required for prelaunch activities, including overseas travel to launch and tracking sites. The amount of travel required for this purpose is directly related to both the number and complexity of the launches.

B. Scientific and Technical Meeting Travel:

Travel to scientific and technical meetings and seminars permits employees engaged in research and development to participate at both Govenment-sponsored and nongovernment-sponsored seminars. This participation allows personnel to benefit from exposure to technological advances in the field which arise outside NASA, as well as allowing personnel to present both accomplishments and problems to their associates. Many of the Government-sponsored meetings are working panels convened to solve certain problems for the benefit of the Government.

C. Management Operations Travel:

Management and operations travel includes travel for the direction and coordination of general management matters and travel by officials to review the status of programs. It includes travel by functional managers in such areas as personnel, financial management, and procurement. This category also includes the cost of travel in and around the Centers, including bus and taxi services and rental of motor vehicles; travel of unpaid members of research advisory committees; and initial duty station, permanent change of assignment, and other family travel expenses.

FACILITIES

A. Rental of Real Property:

Rental of real property includes the rental of building space directly by NASA or through the General Services Administration to meet offsite office, warehousing, and other requirements which cannot otherwise be provided for in existing buildings at the NASA Centers. Most of the funding is required for rental of the NASA Headquarters complex of buildings in the District of Columbia, and nearby Maryland and Virginia

that are either Government-owned or leased for which NASA must provide rental payments to the General Services Administration in accordance with P.L. 92-313. Also included in this item is the rental of trailers required to accommodate special short-term needs.

B. Maintenance and Related Activities:

Maintenance and related activities includes the recurring day-to-day maintenance of facilities (grounds, buildings, structures, etc.) and of their equipment which is accomplished by non-Civil Service personnel. This involves the mowing and care of grassy areas, care of trees and shrubs, elevators, cranes, pressure vessel inspections, painting and protective coatings, general buildings maintenance, and the maintenance of installed mechanical, electrical, and other systems. In addition, this item includes feasibility studies, project design, construction supervision, inspection, and other institutional engineering functions. Included also, are any applicable costs associated with recurring facility work as well as materials, hardware, and equipment used in facility maintenance activities whether accomplished by Civil Service personnel or contractors. In the case of equipment, related maintenance and other services are reflected for office, shop, laboratory and other facilities equipment as well as administrative intercommunications and television monitoring equipment.

C. Custodial Services:

Custodial services include janitorial and building cleaning services; pest control; fire protection services; security services including badging and identification; lock and safe repair; trash and refuse handling; window blinds and light fixture cleaning; light fixture replacement; and laundry and dry cleaning of facility-related items.

D. Utilities Services:

Utilities services include the purchase of utilities including electricity, natural gas, fuel oil, coal, steam, propane, and other fuel commodities as well as water and sewage treatment services. Also included are the related operating costs of the utility plants and systems and the cost of plant maintenance.

TECHNICAL SERVICES

A. Automatic Data Processing:

1. Equipment:

This category provides for the lease, purchase, and maintenance of general purpose data processing equipment which supports institutional operations at each installation. Excluded is equipment dedicated to specific research or to operational systems which is funded from the Research and Development appropriation.

2. Operations:

Operations services include programming, computer operations and related services. Institutional-type applications include payroll, personnel data, logistics, and procurement records and reports.

B. Scientific and Technical Information and Educational Programs:

1. Libraries:

The technical libraries are established to provide Center staffs with books, periodicals, technical reports, and other documentation.

2. Education and Information Programs:

The educational and informational programs provide for the documentation and dissemination of information about the agency's programs to the general public, the educational community at the elementary and secondary levels, and the mass communications media. Assistance to the mass communications media includes the assembly and exposition of newsworthy material in support of requests, and takes such form as press kits, news releases, television and radio information tapes and clips, and feature material.

C. Shop Support and Services:

Shop support and services include general fabrications shops, reliability and quality assurance activities, safety, photographic services, graphics, and audio visual material.

MANAGEMENT AND OPERATIONS

A. Administrative Communications:

Included in this category are costs of leased lines; long distance tolls; teletype services; and local telephone service.

B. Printing and Reproduction:

Included in this category are the costs for duplicating, blueprinting, microfilming, and other photographic reproductions. Also included in this category are Government Printing Office printing costs, contractual printing and the related composition and binding operations.

C. Transportation:

Transportation services include the operation and maintenance of all general purpose motor vehicles used by both civil service and support contractor personnel. The cost of movement of supplies and equipment by commercial carriers are also in this category.

D. Installation Common Services:

Installation common services include support activities at each installation such as: occupational medicine and environmental health; mail service; supply management; patent services; administrative equipment; office supplies and materials; operation of photocopy equipment; chart and related art work; and postage.

DISTRIBUTION OF PERMANENT POSITIONS BY INSTALLATION

Installation	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Johnson Space Center	3,532	3,546	3,509	3,445
Kennedy Space Center	2,179	2,207	2,193	2,187
Marshall Space Flight Center	3,760	3,715	3,636	3,561
National Space Technology Laboratories	102	104	104	103
Goddard Space Flight Center	3,575	3,548	3,468	3,440
Wallops Flight Center	407	408	398	395
Ames Research Center	1,669	1,677	1,666	1,653
Dryden Flight Research Center	490	490	480	461
Langley Research Center	3,071	3,069	3,015	2,990
Lewis Research Center	2,921	2,938	2,858	2,835
Headquarters	1,531	1,535	1,504	1,493
Total, Permanent Positions	23,237	23,237	22,831	22,563

SUMMARY OF BUDGET PLAN BY INSTALLATION
(Thousands of Dollars)

Johnson Space Center	146,654	150,296	154,163	156,466
Kennedy Space Center	113,765	118,431	120,907	128,149
Marshall Space Flight Center	143,445	140,857	148,276	148,884
National Space Technology Laboratories	2,732	3,488	4,527	4,689
Goddard Space Flight Center	123,853	124,139	128,230	131,197
Wallops Flight Center	15,020	15,205	15,493	16,330
Ames Research Center	57,730	59,212	63,761	65,839
Dryden Flight Research Center	18,247	19,481	19,557	19,791
Langley Research Center	102,019	104,579	107,996	110,258
Lewis Research Center	84,916	93,780	92,513	95,800
Headquarters	81,125	84,532	86,046	87,497
Total	889,506	914,000	941,469	964,900

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES

RESEARCH AND PROGRAM MANAGEMENT

DISTRIBUTION OF PERMANENT POSITIONS BY PROGRAM

Program Office and Program	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
SPACE TRANSPORTATION SYSTEMS	6,832	6,883	6,617	6,503
Space Shuttle	5,286	4,412	4,909	4,355
Space flight operations	1,081	2,082	1,300	1,791
Expendable launch vehicles	465	389	408	357
SPACE SCIENCE	2,357	2,313	2,346	2,089
Physics and astronomy	1,838	1,788	1,836	1,612
Planetary exploration	255	267	246	215
Life sciences	264	258	264	262
SPACE AND TERRESTRIAL APPLICATIONS	1,911	1,977	2,022	2,208
Space applications	1,837	1,902	1,952	2,139
Technology utilization	74	75	70	69
AERONAUTICS AND SPACE TECHNOLOGY	5,798	5,735	5,654	5,639
Aeronautical research and technology	3,887	3,925	3,896	3,921
Space research and technology	1,348	1,286	1,247	1,216
Energy technology	563	524	511	502
SPACE TRACKING AND DATA SYSTEMS	797	782	795	786
Tracking and data acquisition	797	782	795	786
Subtotal, Direct Positions	17,695	17,690	17,434	17,225
Center Management and Operations Support Positions	5,542	5,547	5,397	5,338
Total, Permanent Positions	23,237	23,237	22,831	22,563

SUM 12

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES
RESEARCH AND PROGRAM MANAGEMENT
DISTRIBUTION OF BUDGET PLAN BY FUNCTION BY INSTALLATION
(Thousands of Dollars)

FUNCTION	Total NASA	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	National Space Technology Laboratories	Goddard Space Flight Center	Wallops Flight Center	Ames Research Center	Dryden Flight Research Center	Langley Research Center	Lewis Research Center	Headquarters
Personnel and Related Costs												
1978 Actual	677,450	110,801	64,543	115,638	2,648	102,718	9,978	48,214	13,777	84,607	71,998	52,528
1979 Budget	695,093	113,183	66,705	114,413	2,823	104,343	10,313	49,377	13,798	85,568	80,253	54,317
1979 Current	720,924	118,022	70,123	120,323	3,083	108,433	10,521	52,584	14,396	89,337	78,334	55,766
1980 Estimate	727,176	118,522	70,502	119,961	3,151	110,150	10,749	53,514	14,270	89,940	80,524	55,893
Travel												
1978 Actual	17,042	3,240	2,120	2,326	84	2,308	316	1,101	306	1,854	1,002	2,385
1979 Budget	18,741	3,626	2,338	2,382	65	2,476	348	1,230	388	2,156	1,187	2,543
1979 Current	18,573	3,505	2,416	2,492	92	2,481	372	1,218	369	2,098	1,126	2,494
1980 Estimate	19,797	3,781	2,368	2,684	99	2,672	406	1,313	415	2,154	1,208	2,697
Facilities Services												
1978 Actual	91,965	15,876	22,023	11,775	---	9,897	2,796	5,093	2,457	8,148	8,912	4,988
1979 Budget	102,841	17,560	27,906	10,598	350	9,895	2,959	5,309	3,628	9,321	9,705	5,610
1979 Current	100,757	14,945	26,216	11,849	1,094	9,560	3,100	6,675	2,448	9,268	10,026	5,576
1980 Estimate	113,190	17,667	31,421	12,395	1,173	10,288	3,398	7,439	2,661	10,192	10,894	5,662
Technical Services												
1978 Actual	40,435	7,331	5,733	5,636	---	2,169	405	621	226	2,386	732	15,195
1979 Budget	40,357	6,785	6,182	6,418	50	2,046	449	607	348	1,825	565	15,082
1979 Current	39,723	6,395	6,444	5,728	41	2,246	346	686	409	1,721	418	15,289
1980 Estimate	42,288	7,006	6,987	5,588	41	2,325	524	909	458	2,032	429	15,989
Management and Operations												
1978 Actual	62,614	9,405	19,346	8,070	---	6,761	1,525	2,701	1,481	5,024	2,272	6,029
1979 Budget	56,968	9,142	15,300	7,046	200	5,379	1,136	2,689	1,319	5,709	2,070	6,978
1979 Current	61,492	11,296	15,708	7,884	217	5,510	1,154	2,598	1,935	5,662	2,609	6,919
1980 Estimate	62,449	9,490	16,871	8,256	225	5,762	1,253	2,664	1,987	5,940	2,745	7,256
TOTAL												
1978 Actual	889,506	146,654	113,765	143,445	2,732	123,853	15,020	57,730	18,247	102,019	84,916	81,125
1979 Budget	914,000	150,296	118,431	140,857	3,488	124,139	15,205	59,212	19,481	104,579	93,780	84,532
1979 Current	941,469	134,183	120,907	148,276	4,527	128,230	15,493	63,761	19,557	107,996	92,513	86,046
1980 Estimate	964,900	156,466	128,149	148,884	4,689	131,197	16,330	65,839	19,791	110,258	95,800	87,497

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

RESEARCH AND PROGRAM MANAGEMENT*

For necessary expenses of research in Government laboratories, management of programs and other activities of the National Aeronautics and Space Administration, not otherwise provided for, including uniforms or allowances therefor, as authorized by law (5 U.S.C. 5901-5902); awards; [purchase (not to exceed one, for replacement only of one or more existing aircraft, at least one of which shall be an administrative aircraft, which existing aircraft may be exchanged in part payment);] hire, maintenance and operation of administrative aircraft; purchase (not to exceed [twenty-nine] *thirty-two* for replacement only) and hire of passenger motor vehicles; and maintenance and repair of real and personal property, and not in excess of [$25,000] *$75,000* per project for construction of new facilities and additions to existing facilities, [and not in excess of $50,000 per project for] *repairs, and* rehabilitation and modification of facilities; [$910,500,000] *$964,900,000: Provided*, That contracts may be entered into under this appropriation for maintenance and operation of facilities, and for other services, to be provided during the next fiscal year: *Provided further*, That not to exceed $25,000 of the foregoing amount shall be available for scientific consultations or extraordinary expense, to be expended upon the approval or authority of the Administrator and his determination shall be final and conclusive. (*42 U.S.C. 2451, et seq.; Department of Housing and Urban Development—Independent Agencies Appropriation Act, 1979; additional authorizing legislation to be proposed.*)

RESEARCH AND PROGRAM MANAGEMENT

Program and Financing (in thousands of dollars)

Identification code 80-0103-0-1-999	Budget year			Costs and obligations		
	1978 actual	1979 est.	1980 est.	1978 actual	1979 est.	1980 est.
Program by activities:						
Direct program:						
1. Space transportation systems	375,979	383,919	396,600	371,736	383,919	396,600
2. Scientific investigations in space	117,416	119,600	121,000	115,775	119,600	121,000
3. Space and terrestrial applications	97,542	117,000	119,700	96,437	117,000	119,700
4. Space research and technology	62,275	66,950	66,800	61,576	66,950	66,800
5. Aeronautical research and technology	170,731	189,200	194,100	168,269	189,200	194,100
6. Energy technology	24,319	23,000	23,700	23,626	23,000	23,700
7. Supporting activity	41,244	41,800	43,000	40,432	41,800	43,000
Total, direct program	889,506	941,469	964,900	877,851	941,469	964,900
Reimbursable program:						
1. Space transportation systems	1,128	1,440	1,260	1,107	1,440	1,260
2. Scientific investigations in space	93	30	20	108	30	20
3. Space and terrestrial applications	9,708	5,310	4,110	9,460	5,310	4,110
4. Space research and technology	22			3		
5. Aeronautical research and technology	405	250	130	398	250	130
6. Energy technology	12,866	10,850	9,620	12,582	10,850	9,620
7. Supporting activity	9,840	15,420	16,560	9,787	15,420	16,560
Total reimbursable program	34,062	33,300	31,700	33,445	33,300	31,700
Total program costs, funded	923,568	974,769	996,600	911,296	974,769	996,600
Change in selected resources (undelivered orders)				12,272		
10.00 Total	923,568	974,769	996,600	923,568	974,769	996,600
Financing:						
Offsetting collections from:						
11.00 Federal funds				−25,164	−27,231	−26,794
14.00 Non-Federal sources				−8,898	−6,069	−4,906
25.00 Unobligated balance lapsing				255		
Budget authority				889,761	941,469	964,900
Budget authority						
40.00 Appropriation				889,761	910,500	964,900
44.20 Supplemental for civilian pay raises					30,969	
Relation of obligations to outlays						
71.00 Obligations incurred, net				889,506	941,469	964,900
72.40 Obligated balance, start of year				57,183	74,276	76,845
74.40 Obligated balance, end of year				−74,276	−76,845	−77,645
77.00 Adjustments in expired accounts				−2,229		
90.00 Outlays, excluding pay raise supplemental				870,184	909,000	963,031
91.20 Outlays from civilian pay raise supplemental					29,900	1,069

Food Systems Technology - developing nutritional requirements and food processing systems in support of human space flight.

Environmental Effects Analysis - manage efforts to develop the data base and conduct analyses to ascertain any environmental impact of STS operations.

Supporting Technology Advanced Developments - development of prototypes, long lead time systems and new procedures and software for advanced systems.

Operations - operational planning, crew selection and training, medical operations, space transportation system flight control, experiment/payload flight control for attached payloads and STS utilization planning/ payload accommodation studies.

Life Sciences:

Medical Research - establishing human baseline data, investigating and developing countermeasures to solve space medicine problems, and developing information techniques and equipment to support medical operations and medical experiments.

Spacelab Payloads - development of Spacelab life sciences research capability through common operating research equipment development. Defining, developing and integrating inflight biomedical experiments. Providing for the integration of dedicated life science Spacelab experiments and integration for human studies experiments.

Lunar and Planetary Geosciences - developing and maintaining the technical discipline base for lunar and planetary geosciences and extraterrestrial sample handling techniques.

Resource Observations - provide a discipline base for resource observations applications, including airborne techniques and space-based flight sensors. Current emphasis includes the application of Landsat and other data to agricultural crop forecasting.

SUPPORTING

Technology Experiments in Space - management of Orbiter experiments program. Definition and development of experiments in areas consistent with other JSC space roles.

Energy Systems - conducting Satellite Power Systems definition activities.

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1980 ESTIMATES

LYNDON B. JOHNSON SPACE CENTER

DESCRIPTION

The Lyndon B. Johnson Space Center is located approximately 20 miles southeast of downtown Houston, Texas. Total NASA-owned land at the Houston site consists of 1,620 acres. The Center also utilizes an additional 54,080 acres at the White Sands Test Facility, Las Cruces, New Mexico. The total capital investment of the Lyndon B. Johnson Space Center, including fixed assets in progress and contractor-held facilities at various locations and the White Sands Test Facility, as of September 30, 1978, was $709,948,000.

CENTER ROLES AND MISSIONS

The Johnson Space Center (JSC) was established in November 1961, in response to the need for NASA to designate a primary Center to manage the design, development and manufacture of manned spacecraft; for selection and training of astronaut crews; and the conduct of manned space flight missions. It was necessary to focus this responsibility in the Federal laboratory since the Government was to be the customer, consumer and facility owner of an activity which was viewed as possessing considerable risk and much uncertainty because of the total lack of previous experience. This need continued as the Nation proceeded towards more ambitious undertakings such as the Apollo program, the Skylab program, the Apollo Soyuz Test Project and the current Space Shuttle program. In order to meet this responsibility, JSC has developed unique areas of recognized technical excellence within the civil service staff and facilities of superior merit; that is, major technical facilities which constitute a national resource. The principal and supporting roles are:

PRINCIPAL

Manned Vehicles - development of manned space vehicles and associated supporting technology, including:

Space Shuttle - development of the Orbiter and lead Center for management of the Shuttle system. Providing sustaining engineering and logistical support for Space Transportation System (STS) hardware. Includes Shuttle configuration management, Shuttle sustaining engineering and Orbiter operational procurement.

Advanced Missions - focus is on orbital systems and advanced transportation systems.

Environmental and Crew Support Systems - develop and demonstrate Environmental Control and Life Support Subsystems (EC/LSS) and Extra Vehicular Activity (EVA) systems suitable for the space transportation systems and other advanced needs.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
I. Personnel and Related Costs	110,801	113,183	118,022	118,522
II. Travel	3,240	3,626	3,505	3,781
III. Facilities Services	15,876	17,560	14,945	17,667
IV. Technical Services	7,332	6,785	6,395	7,006
V. Management and Operations	9,405	9,142	11,296	9,490
Total, fund requirements	146,654	150,296	154,163	156,466

Distribution of Permanent Positions by Program

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Direct Positions				
Space Transportation Systems	2,599	2,628	2,581	2,539
Space shuttle	2,305	2,032	2,165	1,907
Space flight operations	294	596	416	632
Space Science	136	136	136	133
Planetary exploration	40	52	40	39
Life sciences	96	84	96	94

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Space and Terrestrial Applications	207	199	206	206
Space applications	203	195	202	202
Technology utilization	4	4	4	4
Aeronautics and Space Technology	33	45	32	30
Aeronautical research and technology	3	---	3	3
Space research and technology	8	10	8	7
Energy technology	22	35	21	20
Subtotal, direct positions	2,975	3,008	2,955	2,908
Center Management and Operations Support Positions	557	538	554	537
Total, permanent positions	3,532	3,546	3,509	3,445

PROGRAM DESCRIPTION

SPACE SHUTTLE

1,907 Permanent Positions (Civil Service)

The 1980 staffing provides for continuation of design, development, test and evaluation activity on a schedule consistent with the major program milestones including the first manned orbital flight. Activities will continue consistent with a phased delivery of the total Orbiter fleet. Procurement of necessary initial flight and ground support equipment will be continued.

The Space Shuttle Program Office of the Lyndon B. Johnson Space Center (JSC) has program management responsibility for program control, overall systems engineering, and Space Shuttle system integration. The Space Shuttle Program Office (SSPO) provides management of the "Lead Center" functions as related to the Space Shuttle Program and the overall systems management and integration of all elements of the program. The Space Shuttle Orbiter Project Office provides overall management of the design, development, test and production of the Orbiter system. This includes management of various elements of the total Orbiter system (e.g., structures, propulsion, power, avionics, etc.) and to lower elements within the subsystems.

In order to adequately integrate all vehicle systems into an efficient operating system, many detailed interfaces and functional performance features must be identified and defined. Specific interface control documents are identified and established including both flight systems and flight to ground systems. General capability and performance criteria are established for special areas of consideration such as electromagnetic compatibility and lightning protection. For proper systems operations, systems performance data and operational information are prepared such as operational data books, mission requirement documents, etc.

Although major Shuttle flight system elements have been individually managed through designated Shuttle element project offices and related provisioning contractors, a relatively large quantity of supporting equipment is supplied to the program through other elements of JSC. Examples of such equipment are: extravehicular mobility unit, portable oxygen system, closed circuit television, survival radio sets, dosimetry, crew equipment, photographic camera systems, and bioinstrumentation. Each represents a multitude of engineering, management, and evaluation activities. These include definition of requirements, establishment of contract, management of contractor projects, evaluation of design and performance, and provisioning of equipment in a certified "ready for use" configuration. Mission use of equipment also requires onsite processing for preparation and related reconditioning for sequential missions.

Throughout the Orbiter program, particular attention is given to prediction of vehicle performance in each area of function, to analysis of design, establishment and conduct of necessary tests and rectification of actual vs. predicted performance difference. Since the Orbiter represents an integrated complex of technical and engineering disciplines, specific test, evaluation and analysis subtasks have been assigned to the variety of technical organizations at JSC. Included in these tasks are: providing technical expertise in the Orbiter life support systems; performing engineering analysis, design definition, performance evaluation, and breadboard testing for communications and tracking systems ground testing; providing expertise in guidance, navigation, control, instrumentation and electrical power distribution; management and operation of environmental test chambers; analysis, evaluation and component testing of the Orbiter hydraulics system, auxiliary power unit, orbital maneuvering system components, reaction control engine performance, reaction control system engine valve leak detection techniques and development of initiator firing units; analysis and laboratory testing for vehicle attachment and separation systems; design analysis of total Shuttle systems, Shuttle/payload interface design, crew station evaluation and design, Shuttle airlock design evaluation, etc.; conduction of engineering analysis to determine overall vehicle performance characteristics in the area of aerodynamic performance, flight characteristics, performance, and dynamics including aeroelasticity.

The successful flight and operational performance of the Space Shuttle is dependent on the proper functioning of integrated electronic equipments. Collectively, these are termed the Integrated Avionics System. Avionics provide the Shuttle pilots and crew with the total assessment and command capability necessary to manage, fly and operate the vehicle. Because of the criticality of this system, very close attention is given to the identification of performance requirements, systems design, and integrated performance.

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A variety of avionic elements are included within the Space Shuttle system, each of which requires attention of a group of technical experts. These elements include: guidance, navigation and control, data processing, communication and tracking; instrumentation, displays and controls, solid rocket booster control and recovery interface, power and control, and external tank propellant control and instrumentation.

Avionics and software testing and checkout in the Electronics Systems Test Laboratory and the Shuttle Avionics Integration Laboratory have effectively supported the Approach and Landing Test (ALT) effort, and configuration changeover for Orbital Flight Testing (OFT) is scheduled to start in 1979. Their purpose is to verify the functional performance of Shuttle Integrated Avionics System and validate the system design and verify compatibility of the various radio frequency communication links.

For OFT training, the Orbiter Aeroflight Simulator (OAS) was updated to the Orbiter Vehicle 102 configuration to become the second crew station in the Shuttle Mission Simulator (SMS) complex. This complex will be the main training facility but will be supplemented by a number of part task trainers and specialized training devices. Initial training operations using the motion base of the SMS and full integrated simulations (SMS tied into MCC) will begin in early 1979. This schedule will provide adequate support for the first manned orbital flight. The training schedule requires 20 training hours per week per crew station. Involved in simulator operations are the performance of simulator readiness, runs prior to the start of a scheduled program, assuring that all aspects of the simulator required for the day's operation are functioning correctly; the operation of the simulators during the exercises; and the documentation of any abnormal operation identified in the simulator performance or configuration.

The Mission Control Center (MCC) update involves the management of the design, development, integration, and testing of all MCC software required to support the Shuttle Orbital Flight Test (OFT) program. This includes modifications to old programs, new or replacement programs, their integration in the MCC, the integration of the MCC software and hardware, and software of the MCC for simulation, training, and actual flight operations. This is a major design change to the MCC software and requires new programs for the telemetry, command, tracking, and communications programs.

Orbital Flight Support includes a wide variety of planning activities ranging from operational concepts and techniques to detailed systems operational procedures and checklists. Tasks include flight system and software handbooks, flight rules, detailed crew activity plans and procedures; development of mission control center and network systems requirements; and, operations input to the initial planning for the selection and operation of Shuttle OFT payloads.

Specific OFT flight planning and software products include preliminary operational flight profiles and operational flight profiles at launch minus 13 and four months respectively for each flight. A payloads opportunities list keyed to each profile is provided in approximately the same timeframe. The flight planning activity encompasses the flight design, flight analysis, and utilization planning tasks for the OFT program. The flight

design and flight analysis tasks include developing profiles on a preflight basis and supporting the development of flight techniques for OFT.

Software development is concerned with the development, formulation, coordination, and implementation of the requirements for all Orbiter onboard computer software in the guidance, targeting, navigation, and systems management.

SPACE FLIGHT OPERATIONS — 632 Permanent Positions (Civil Service)

JSC's support of the Spacelab development effort includes establishing and controlling Shuttle interface with the Spacelab, for overall safety requirements for the Shuttle/Spacelab combination, and support of MSFC in the performance of its assigned responsibilities. JSC is responsible for crew training in conjunction with flight hardware, and the development and operation of Shuttle/Spacelab simulators and trainers as well as Spacelab support software resident in the Orbiter general purpose computer.

Upgrading the capability of the Mission Control Center to configure the MCC with the flight capability to support two Orbiters simultaneously, a ground simulation network, and a MCC launch site interface requires additional hardware, equipment, and software. Work will also be done to focus on determining the most efficient method of operating the STS, provide for integrating payloads on the OFT flights, and provide facilities for command and control of Shuttle/Spacelab attached payloads.

The advanced programs objective is to provide technical as well as programmatic data for the definition and evaluation of potential future space programs and systems. In support of these activities, advanced development and advanced studies are conducted to obtain significant performance and reliability improvements and to reduce future program risks and development costs through the effective use of new technologies. In fiscal year 1980, the advanced studies effort will concentrate on potential future early space stations and orbital transfer vehicles. Advanced operational concepts related to integrated launch operations, orbital assembly of large structures and orbital capability will be investigated in further detail. The advanced development effort will support the advanced study concepts related to integrated launch operations, orbital assembly of large structures and orbital capability will be investigated in further detail. The advanced development effort will support the advanced study concepts in all the major technical disciplines. Orbital operations studies will be supported with design and testing of concepts applicable to assembly, maintenance and operation of large structures and complex satellite systems, rendezvous and inspection, and satellite retrieval and repair. Consumables management and advanced instrumentation studies will also be continued, and the funding will provide for testing and evaluation of major regenerative life support subsystems.

PLANETARY EXPLORATION — 39 Permanent Positions (Civil Service)

The Center supports the agency's Planetary Exploration Program in the area of geosciences where a strong, active research group is required to support future programs, to provide curatorial support, to assist in information dissemination and to interact with outside scientists. To provide this support the research group must make an active contribution to our knowledge of the compositions, structures and evoluntionary histories of the solid bodies of the solar system. Therefore, the Center has an ongoing program of analysis of planetary materials and of remote sensing data, a theoretical studies program and is involved in the development of remote sensing instrumentation. The definition of geoscience requirements for future planetary flight missions is an important role for the geoscience group which is involved in extensive cooperation with the planetary science community.

LIFE SCIENCES — 94 Permanent Positions (Civil Service)

The Johnson Space Center has the lead role in evaluating human physiological changes associated with the space environment and providing effective countermeasures to assure crew health and optimal performance. The scientific activities are to define, develop and integrate biomedical experiments for life sciences payloads. Additionally, these experiments are designed to utilize the space environment to accomplish medical and biological research for the benefit of man on Earth.

The medical activities provide for medical contingencies in flight involving onboard health services, training for crewmen, ground-based medical support and medical evaluation of proposed crewmembers. These objectives are supportive of the Center's responsibility for assuring astronaut health and safety, both during flight and on the ground. The accomplishment of these objectives requires a well defined and continuing program that incorporates medical research, operations, laboratory support and clinical medicine.

The bioengineering activities provide integration of dedicated life sciences, Spacelab experiments and integration for human experiments. To this end, experiments will be selected, and experiment hardware development will be initiated.

SPACE APPLICATIONS — 202 Permanent Positions (Civil Service)

The resource observations discipline is divided into three major areas: technology development, flight projects, and applications projects. JSC's responsibility entails the conduct and implementation of major tasks in each of these areas. Efforts are evenly divided among them and include the following specific activities:

1. Technology development is directed toward determining applications of remotely sensed data for agricultural crop identification, crop acreage and yield estimation, forest mapping and inventory, soil moisture

measurement, and vegetation cover monitoring. Studies of data systems and techniques, applicable to these and other applications, are also being conducted.

2. Flight project responsibilities at JSC include the airborne instrumentation research project and Shuttle payload instrument development and integration. Responding to airborne measurement requirements, generated by NASA research and cooperative programs with the Departments of Agriculture, Interior, Defense, Commerce and Energy and various state agencies, JSC develops and implements an aircraft support plan. Involved is the testing, maintenance, and operation of a wide variety of remote sensors which provide data to investigators. Four aircraft, capable of data acquisition from 500 to 63,000 feet, are operated; a Lockheed C-130, two General Dynamics WB-57F's, and a Bell 206B helicopter. They are maintained at nearby Ellington Air Force Base.

Sensors currently being developed by JSC for flight on the Shuttle are the Large Format Stereo Camera and Spaceborne Imaging Radar. In addition, JSC is responsible for mission management of the Office of Space and Terrestrial Application 1 (OSTA 1) payload which includes integration of equipment to the pallet, integrating the payload into the Orbiter, and real time mission support while in orbit.

3. Applications demonstration projects are being conducted with the Department of Interior's Bureau of Land Management to monitor wildland vegetation, the St. Regis Paper Company to map and inventory forestland, the Corps of Engineers to detect and map water impoundments, and the State of Texas to inventory statewide natural resources. The objective of these applications demonstration projects is to transfer aerospace remote sensing systems and techniques to the public and private sectors.

TECHNOLOGY UTILIZATION — 4 Permanent Positions (Civil Service)

The Technology Utilization program transfers new knowledge and innovative technology resulting from NASA's research and development programs for application in industry, medicine and important public sector areas such as urban development. The Technical Planning Office at JSC provides program office direction for the Technology Utilization program at JSC and provides engineering support to analyze the feasibility of space application to ground-based operations, such as: telecare, feeding the elderly, and bioisolation garment.

AERONAUTICAL RESEARCH AND TECHNOLOGY — 3 Permanent Positions (Civil Service)

Studies working towards improving aircraft fire safety through evaluating advanced materials to reduce fire and toxicity threats.

SPACE RESEARCH AND TECHNOLOGY — 7 Permanent Positions (Civil Service)

Systems and design studies are being performed to provide the necessary analytical results which permit the successful transfusion of the technology developed under the research and technology base into systems and experimental programs. One example of this effort is the Orbiter Research and Technology Experiments Program (OEX); the intent of which is to collect research and technology data by utilizing the currently planned Developmental Flight Instrumentation (DFI) and Orbital Flight Instrumentation (OFI) configuration of the Orbiter Vehicle.

ENERGY TECHNOLOGY — 20 Permanent Positions (Civil Service)

Engineering manpower will be used for Space Solar Power System Definition. This will involve in-house engineering definition studies and contract management. The studies will involve a systematic comparative assessment of power conversion options (photovoltaic versus thermal, silicon versus gallium arsenite, etc.); major systems trades such as the location of the space construction activity (low earth orbit versus geo-synchronous orbit); and critical systems definition (rotary joint, phase control, etc.). Also, the studies will provide for a second iteration of elements and emphasize techniques of space construction, construction base definition, logistics and operations, and definition of required development program.

CENTER MANAGEMENT AND OPERATIONS SUPPORT — 537 Permanent Positions (Civil Service)

Center Management and Operations Support is defined as that support or service being provided to all Johnson Space Center organizations which cannot be directly identified to a specific benefitting program or project. The civil service personnel involved are:

Director and Staff - The Center Director, Deputy Director and immediate staff, e.g., Legal, Patent Counsel, Equal Opportunity, Technical Planning, and Public Affairs.

Management Support - Includes a wide range of activity categorized as business management support for programs and functional organizations for the entire Center. Specific functions include resource and budget management, program control, contracting and procurement, personnel management, property management, financial management, resource control, and management systems and analyses.

Operations Support - This is a broad spectrum of activity that is required to maintain and operate facilities, buildings, and equipment; and to provide the normal housekeeping services and logistics support for the personnel who manage and conduct the affairs of the Center. Specific activities are:

Maintenance and operation of all buildings and facilities
Data processing and computer support
Reliability and quality assurance
Centerwide security and protection
Fire protection
Custodial services
Logistics support including transportation, supplies, etc.
Medical care of employees
Photographic and graphic support

PERSONNEL AND RELATED COSTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
I. PERSONNEL AND RELATED COSTS	110,801	113,183	118,022	118,522
Basis of Fund Requirements				
A. Compensation and Benefits				
1. Compensation				
a. Permanent positions	97,447	99,050	103,124	103,366
b. Nonpermanent	1,086	1,134	1,568	1,598
c. Reimbursable detailees	1,334	1,905	1,885	1,993
d. Overtime and other compensation	406	624	589	590
Subtotal, Compensation	100,273	102,713	107,166	107,547
2. Benefits	9,960	9,955	10,306	10,365
Subtotal, Compensation and Benefits	110,233	112,668	117,472	117,912
B. Supporting Costs				
1. Transfer of personnel	161	150	110	145

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
2. Personnel training	407	365	440	465
Subtotal, Supporting Costs	568	515	550	610
Total, Personnel and Related Costs	110,801	113,183	118,022	118,522
A. Compensation and Benefits	110,233	112,668	117,472	117,912
1. Compensation	100,273	102,713	107,166	107,547
a. Permanent positions	97,447	99,050	103,124	103,366

The funds shown above will support 3,445 permanent positions in 1980. The increase from the 1979 budget estimate to the 1979 current estimate is due to the October 1978 pay raise, partially offset by the reduction in civil service positions.

Basis of Cost for Permanent Positions

In 1980 the cost of permanent positions will be $103,366,000, an increase of $242,000 from 1979. This increase results from the following:

Cost of permanent positions in 1979		103,124
Cost increase in 1980		+2,543
Within grade advances and career development		
Full year effect of 1979 actions	+843	
Partial year effect of 1980 actions	+787	
Full year effect of 1978 pay raise	+116	
Two extra paid days in 1980	+797	
Cost of decreases in 1980		-2,301
Turnover savings		
Full year effect of 1979 actions	-740	
Partial year effect of 1980 actions	-1,561	
Cost of permanent positions in 1980		103,366

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	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
b. Nonpermanent positions				
1. Cost	1,086	1,134	1,568	1,598
2. Workyears	128	125	165	160

The increase from the 1979 budget estimate to the 1979 current estimate is due to the additional requirements in the youth opportunity program and the establishment of the part-time employment program. The 1980 plan includes 160 workyears which is reduced from 1979 to reflect the absorption of the part-time program into the permanent position ceiling. This effort will support the following programs as shown:

Program	Workyears
Cooperative training programs	75
Summer programs	33
Youth opportunity programs	31
Other temporaries	21
Total	160

c. Reimbursable detailees	1,334	1,905	1,885	1,993

The military personnel detailed to the Johnson Space Center on a reimbursable basis are individuals experienced in manned flight and related fields. Each individual performs an essential and critical function to the current and future programs.

Individuals with knowledge, experience, and with a "flight" background, are essential to the manned flight programs. The individuals most readily available within the Government ranks are in the military. The additional requirement for keeping the military informed on manned space flight technology is also essential.

One civilian employee, experienced in the field of medicine, is also detailed, on a reimbursable basis, to the Johnson Space Center.

The increase in 1979 over 1978 is due to the addition of new astronauts and mission specialists for the Shuttle programs. The workyears remain level from 1979 to 1980 with cost increases resulting from salary increases and career development.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
d. Overtime and other compensation	406	624	589	590

Overtime in 1980 will be used primarily for the orbital test flights, e.g., crew training, trajectory optimization, data reduction, integration laboratory, and related support activities. In addition, there are numerous source selection boards, earth resources application system verification programs and other activities that necessitate some extension of the normal work day or week. Costs remain essentially level from 1979 to 1980.

2. Benefits	9,960	9,955	10,293	10,342

Following are the amounts of contribution by category:

Category of Costs				
Civil Service Retirement Fund	6,835	7,018	7,297	7,288
Employee life insurance	401	408	410	410
Employee health insurance	1,862	1,824	1,825	1,892
Workman's compensation	567	572	572	573
FICA	30	17	36	36
Incentive Awards	163	115	165	165
Severence pay	102	---	---	---
Other benefits	---	1	1	1
Total	9,960	9,955	10,306	10,365

The increase from the 1979 budget to current estimate is due to the October 1978 pay raise, partially offset by a reduction in civil service positions. The increase in 1980 over 1979 is related to the increases in personnel compensation and reflects the savings resulting from the manpower reductions.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
B. Supporting Costs	568	515	550	610
1. Transfer of personnel	161	150	110	145

This category includes cost of subsistence and temporary expenses, real estate, miscellaneous moving expenses and movement of household goods made necessary with the transferring of personnel. The decrease from the 1979 budget estimate to the 1979 current estimate is due to the fact that some of the cost anticipated in 1979 actually occurred in 1978. The increase in 1980 is due to increased numbers of transfers as a result of the transition to the operational phase of the Shuttle program which will necessitate some reassignment of personnel from JSC to the Kennedy Space Center and vice versa.

2. Personnel training	407	365	440	465

Training is a prime objective to permit employees to advance to more responsible positions. This also provides the Center with more highly motivated and experienced personnel not readily available in the labor market. These funds provide the means to meet the training requirements of the untrained, unskilled minorities, and to provide the training necessary to keep those employees with technological expertise abreast of the latest state-of-the-art in their respective fields. Training increases from the 1979 budget estimate to the 1979 current estimate to reflect 1978 experience and provide for additional "Upward Mobility" training. The increase in 1980 over 1979 reflects higher tuition rates.

TRAVEL

II. TRAVEL	3,240	3,626	3,505	3,781
Basis of Fund Requirements				
A. Program Travel	2,764	3,072	3,054	3,265
B. Scientific and Technical Meeting Travel	120	175	101	115
C. Mangement and Operations Travel	356	379	350	401
Total, Travel	3,240	3,626	3,505	3,781

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
A. Program Travel	2,764	3,072	3,054	3,265

Program travel is specifically required for the accomplishment of the Center's mission and accounts for 86 percent of the travel budget for 1980. Program travel in 1980 will require about 7,929 trips, an increase of 259 trips over those anticipated in the 1979 budget. Travel to support Space Shuttle development and production is expected to continue in 1980 at approximately the same level experienced in 1979. However, travel required to support Space Transportation System operations will increase, particularly in the area of payload development and the generation, review and interchange of the thermal, structural and dynamic mathematical models required for integration of the various payloads.

B. Scientific and Technical Meeting Travel	120	175	101	115

Scientific and technical meeting travel permits employees to participate in meetings and technical seminars with other representatives of the aerospace community. This participation allows them to benefit from exposure to technological advances outside JSC as well as to present both accomplishments and problems to their associates. Many of the meetings are working panels convened to solve certain problems for the benefit of the Government. Approximately 205 trips are planned in 1980 to attend scientific and technical meetings. Symposia and technical seminars related to the earth observation program and lunar samples are a major requirement in this area. The decrease from the 1979 budget estimate to the 1979 current estimate reflects a decrease to approximately the 1978 actual experience. The level of travel in 1980 is expected to remain approximately the same as 1979.

C. Management and Operations Travel	356	379	350	401

Management and operations travel is used for the direction and coordination of general management matters. It includes travel in such areas as personnel, financial management, and procurement activities, travel to the Center's top management to NASA Headquarters and other NASA Centers, and local transportation. The 1979 current estimate was reduced from the 1979 budget estimate to provide for fund requirements in other areas. The increase in 1980 reflects increases in source evaluation board activities.

FACILITIES SERVICES

The Johnson Space Center (JSC) is located on 1,620 acres with a complex of laboratory and office-type buildings as well as test facilities. This complex encompasses 2,785,820 gross square feet of building

space in 22 major buildings. Also included are 11 major technical facilities. This physical plant supports an average daily on-Center population of 7,100 to 7,500 personnel. Many of the test facilities are utilized on schedules involving more than one shift and off-peak hours.

The budget estimates also include certain resources associated with plant needs at the White Sands Test Facility (WSTF) and for facilities used at Ellington Air Force Base (EAFB) under permit from the Air Force.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
III. FACILITIES SERVICES	15,876	17,560	14,945	17,667
Basis of Fund Requirements				
A. Maintenance and Related Services				
1. Facilities	6,965	6,540	4,674	6,717
2. Equipment	431	410	387	394
Subtotal	7,396	6,950	5,061	7,111
B. Custodial Services	2,335	2,378	2,736	3,086
C. Utility Services	6,145	8,232	7,148	7,470
Total, Facilities Services	15,876	17,560	14,945	17,667
A. Maintenance and Related Services	7,396	6,950	5,061	7,111
1. Facilities	6,965	6,540	4,674	6,717

This activity involves not only JSC facilities at Houston but also White Sands Test Facility (WSTF) and Ellington Air Force Base (EAFB). It provides for 219 workyears of effort and is essentially a continuation of that level of effort to be provided in 1979. The reduction from the 1979 budget estimate to the 1979 current estimate reflects a rephasing of support contract funding to align it with the year in which the work is performed. The 1980 estimate provides for full year funding of the contracts and the cost of negotiated support contract wage increases. Major types of support in this area are:

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		

a. Routine facilities work (14 workyears of effort)..... 518

Provides for routine facilities support for utility systems, roads and grounds, and administrative office alteration at JSC, WSTF, and EAFB.

b. Grounds maintenance (24 workyears of effort)..... 419

Provides for mowing and edging of 540 acres of improved land and mowing 775 acres of unimproved land. Also included is cultivation, mulching, fertilizing, insect control, and care of trees and shrubs.

c. Maintenance and operations to include routine maintenance of applicable facilities at:

JSC (98 workyears of effort)..... 3,015
WSTF (63 workyears of effort)..... 1,498

The above activity includes minor maintenance work, including painting at JSC and Ellington Air Force Base.

d. Facilities design and engineering at JSC (20 workyears of effort)..... 503

This includes facility engineering consisting of engineering design, drafting and specifications preparation for construction of facilities, minor construction and repair projects, and other facility and system design and modification tasks. Also included is minor facility support to Ellington Air Force Base.

e. Supplies and facilities equipment..... 764

Included under this category are materials, hardware and equipment that are used to maintain the facilities at JSC and WSTF.

2. Equipment.....	431	410	387	394

a. Equipment maintenance..... 361

Provides maintenance support for administrative equipment at JSC, WSTF, and EAFB and involves mainly office-type equipment services by local businesses.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
b. Closed circuit TV maintenance and operation				33

One workyear is required for the maintenance and operation of JSC's closed circuit TV system for administrative purposes.

B. Custodial Services	2,335	2,378	2,736	3,086

This activity involves 234 workyears of support contractor effort at JSC to provide security guard services, janitorial services, fire fighting and ambulance services. The increase from the 1979 budget estimate is due to the fact that the proposed conversion to the volunteer fire department did not prove feasible. The 1979 current estimate is based on NASA continuing to provide effort (through a support contractor) for primary response, safety inspections and alarm maintenance. The increase in 1980 is due primarily to negotiated support contract wage increases.

1. Security guard services (60 workyears of effort) 1,029

This activity includes:

a. Badging all on-site personnel and visitors.
b. Policing 13,000 vehicles daily at five gates. One gate is covered 24 hours a day, seven days a week, and the other four gates are covered for 12 hours a day, five days a week.
c. Protecting all Government facilities and equipment.

2. Janitorial services (151 workyears of effort) 1,433

Provides janitorial services in these areas:

a. Maintains approximately 2,555,465 square feet of area.
b. Periodically replaces 10,000 lights.
c. Remove 144 cubic yards of trash daily.
d. Laundry services from two off-site firms.

3. Fire Protection (23 workyears of effort) 624

This activity includes:

a. Industrial safety and inspection (e.g., compliance with OSHA regulations)
b. Maintenance of alarms and fixed fire fighting equipment
c. Technical interface with Houston Fire Department for fire fighting activities

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
C. Utilities Services	6,145	8,232	7,148	7,470

Includes purchased utilities and 44 workyears of support contractor effort for the operation and maintenance of the utility distribution system at JSC. The increase from 1978 actual to 1979 current reflects 17.8% rate increase in natural gas and 14.4% increase in electricity. The increase from the 1979 current estimate to the 1980 estimate reflects rate increases partially offset by 8.7% reduction as a result of conversion from natural gas to electricity. The decrease from the 1979 budget to the 1979 current reflects rate increases which were not as great as anticipated. The purchased utilities are outlined below:

	1980 Budget Estimate
1. Electricity	4,529
JSC (135,107 M KWH) WSTF (8,600 M KWH)	
2. Natural gas	1,244
JSC (335,085 MCF) WSTF (17,000 MCF)	
3. Water	179
4. Sewage treatment	188

TECHNICAL SERVICES

IV. TECHNICAL SERVICES	7,332	6,785	6,395	7,006

Basis of Fund Requirements

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
A. Automatic Data Processing				
1. Equipment	2,481	2,249	2,266	2,300
2. Operations	2,401	2,488	2,115	2,540
Subtotal	4,882	4,737	4,381	4,840
B. Scientific and Technical Information				
1. Library	74	81	90	96
2. Education and Information	1,365	688	671	682
Subtotal	1,439	769	761	778
C. Shop Support Services	1,011	1,279	1,253	1,388
Total, Technical Services	7,332	6,785	6,395	7,006
A. Automatic Data Processing	4,882	4,737	4,381	4,840

This activity provides accounting and management information to satisfy requirements of NASA management and external authority. Included is support of all JSC administrative functions and the lease and maintenance costs of all multiuse ADP equipment within JSC's Central Computer Facility. The increase from 1979 to 1980 is due mainly to negotiated support contractor wage increases. The level of effort remains essentially the same.

1. Equipment	2,481	2,249	2,266	2,300

Covered herein are the maintenance costs of all JSC owned ADP equipment and the lease costs of all leased ADP hardware within the Central Computer Facility. These hardware systems includes four Univac 1108, one Univac 1110, one Univac 9300, one IBM 360/22, one IBM 360/30, one CDC 3200, and one Mohawk (data entry) computer system. Also included is associated peripheral equipment such as two microfilm processors, various terminals, and keypunch.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
2. Operations	2,401	2,488	2,115	2,540

ADP systems supported include Institutional Management, Financial and Accounting, Procurement, Tracking and Contractual Status, Personnel Management Information, and Utility Branch.

a. Computer programming requiring 24 workyears of effort at a cost of $903,000.

b. Keypunch, operators, and other support personnel requiring 48 workyears plus purchased supplies, materials, and software programs for a total of $1,637,000.

B. Scientific and Technical Information	1,439	769	761	778

This activity, requiring 37 support contractor workyears, provides for the operation of a technical library at JSC, a public affairs educational and informational program, and support to the Center in the provision of various scientific and technical information services. The modest increase in 1980 is due to negotiated support contractor wage increases.

1. Library	74	81	90	96

Six workyears provide cataloging and indexing services and provide initial distribution of publications in the operation of the JSC Technical Library. This includes, on a monthly basis, cataloging about 170 books, indexing approximately 730 reports, and distributing about 50,000 publications.

2. Education and information	1,365	688	671	682

Thirty-one workyears of support contractor effort are used to support a JSC public affairs program. Included are: exhibit management and refurbishment; visitor orientation tours; lecturing; mail answering services; and other activities.

C. Shop Support and Services	1,011	1,279	1,253	1,388

Fifty-one workyears of support contractor effort provide the Center with support in the areas of graphics, publications, and audiovisual material. Micro-images are prepared from hard copy and vice-versa. Editorial services are provided for JSC publications. Graphic materials are prepared for use in presentations and senior

management meetings. Motion pictures, from script to screen, and film clips are produced to support Center Management and Public Affairs. Various kinds of film are processed and reproductions and reprints made. The increase from 1979 to 1980 is due to negotiated support contractor wage increases.

MANAGEMENT AND OPERATIONS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
V. MANAGEMENT AND OPERATIONS	9,405	9,142	11,296	9,490
Basic of Fund Requirements				
A. Administrative Communications	2,271	2,737	2,426	2,437
B. Printing and Reproduction	823	572	750	761
C. Transportation	954	814	3,120	825
D. Installation Common Services	5,357	5,019	5,000	5,467
Total, Management and Operations	9,405	9,142	11,296	9,490
A. Administrative Communications	2,271	2,737	2,426	2,437

Communications support for JSC and WSTF consist of local telephone service, long distance telephone service, and various kinds of other nontelephone communications. The same level of support is projected for FY 1980 as occurred in FY 1979. The decrease from the 1979 budget estimate to the 1979 current estimate is primarily the result of transferring postage from communications to installation support services.

1. Local telephone service 1,330

The major part of this covers 3,580 Centrex lines and 6,330 telephone instruments at JSC. Also included are 292 telephones at WSTF and local telephone service at: Draper Labs, Cambridge, MA; Grumman, Bethpage, NY; and SAMSO, El Segundo, CA. About 175 local circuits at JSC and 2 at WSTF (Fire Alarms, Burglar Alarms, Public Address, Data, etc.) are included within this category.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
2. Long distance telephone service				967

a. Federal Telecommunications System (FTS) use was 932,615 calls in FY 1978.

b. Tolls or commercial long distance calls are about 1,000 a month at JSC and 5 a month at WSTF.

c. Four leased lines are employed: two circuits from WSTF to Las Cruces, NM, and two circuits from JSC to GSA in Austin, TX. All are teletype circuits except the WSTF/Las Cruces, NM, which are voice.

3. Nontelephone communications				140

a. Teletype costs include: Western Union Lease costs, DOD Classified Teletype Network Access costs, TWX or message charges.

b. Other communications include a UPI Wire Service for the Public Affairs Office and eight radio networks (Fire/Security, Custodial, etc.).

B. Printing and Reproduction	823	572	750	761

JSC's basic printing requirements are handled by maintaining an on-site printing plant operated by JSC personnel. This printing plant produces approximately 36,000,000 units of printing each year. In addition to this on-site printing plant, JSC must also purchase from private firms, via Government Printing Office contracts, about 43,000,000 units of printing each year. This purchased printing is a combination of an overflow requirement that cannot be handled with the on-site workload and often is of such type that cannot be handled with the limited capability of the on-site equipment. The 1979 current estimate reflects the transferring of shuttle printing from contractor to in-house.

C. Transportation	954	814	3,120	825

Transportation functions at JSC involve seven workyears of effort. Also included are administrative aircraft maintenance costs, and lease of trucks from General Services Administration (GSA). The 1979 current estimate is higher than the 1979 budget estimate because of the proposed replacement of an administrative aircraft in 1979. The level of effort for these services in 1980 is expected to be the same as that in 1979.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
D. Installation Common Services	5,357	5,019	5,000	5,467

These services, requiring 163 workyears of support contractor effort, support Center management and staff activities, provide medical services, and cover various installation support services. The increase from FY 1979 to 1980 is due primarily to negotiated support contractor wage increases.

1. Center management and staff 38

Costs involved in patent searches and applications.

2. Medical services 1,226

This activity provides support in two main categories: occupational medicine and environmental health. Total support contractor workyears required is 39.

a. Occupational medicine 871

Occupational medicine consists of operation of the JSC on-site clinic, emergency assistance at Ellington Air Force Base (EAFB), providing physicals for JSC personnel at Downey, California, medical consultation and crew test support. Total workyears are 26.

b. Environmental health 355

Environmental health consists of industrial hygiene, radiological health, and an environmental health lab at a total of 13 workyears.

3. Installation support services 4,203

Included here, requiring 124 workyears of support contractor effort, are all administrative support services not specifically identified elsewhere. Among these services are the purchase of administrative supplies and equipment, the cataloging of supplies and equipment, warehousing and storage, moving and hauling, forms distribution, vehicle drivers and dispatchers, Ellington Air Force Base (EAFB) support, and many smaller miscellaneous services.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		

a. Administrative supplies, materials and equipment..... 1,337

Included in this category are supplies, materials and equipment that are used to support the administrative function at JSC and WSTF.

b. Cataloging of supplies and equipment..... 312

Twenty workyears are required for identification and cataloging requests for supplies into the proper Federal Supply Groups, placing orders on the proper Federal Schedule Contracts, maintaining a stores stock catalog, etc.

c. Warehousing and storage..... 908

Fifty-eight workyears are needed to operate a central receiving depot for supplies, a warehousing and storage function (including bonded storage and storage of hazardous materials) and a stock issuance service.

d. Postage..... 482

Administratively handled by NASA Headquarters.

e. Moving and hauling..... 595

Thirty-eight workyears are required to handle shipping and packing of supplies and equipment both locally and for long distance movement, moving and hauling of items locally, and delivery of items purchased from local firms.

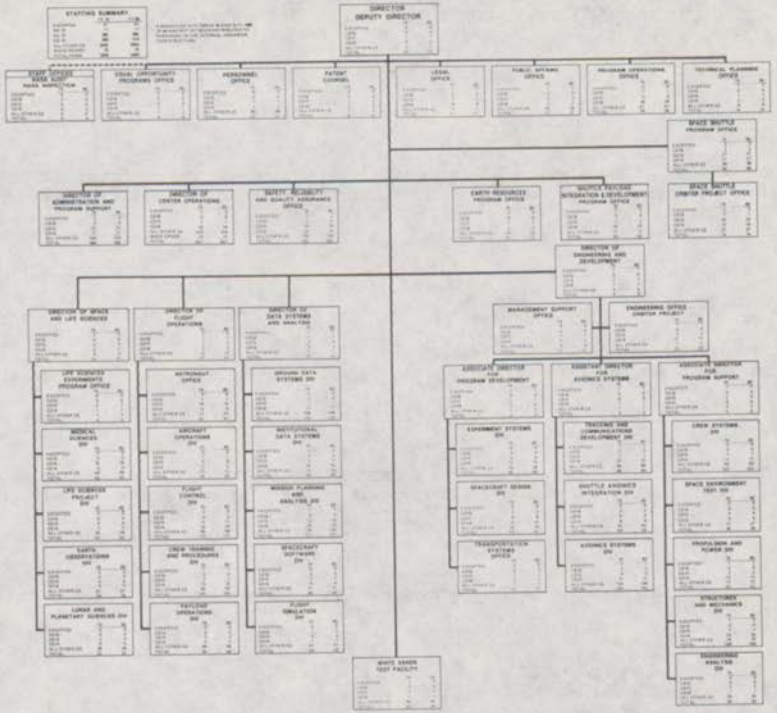
f. Forms distribution..... 128

Eight workyears are required for the distribution of approximately 600,000 forms and publications each year.

g. Administrative support..... 441

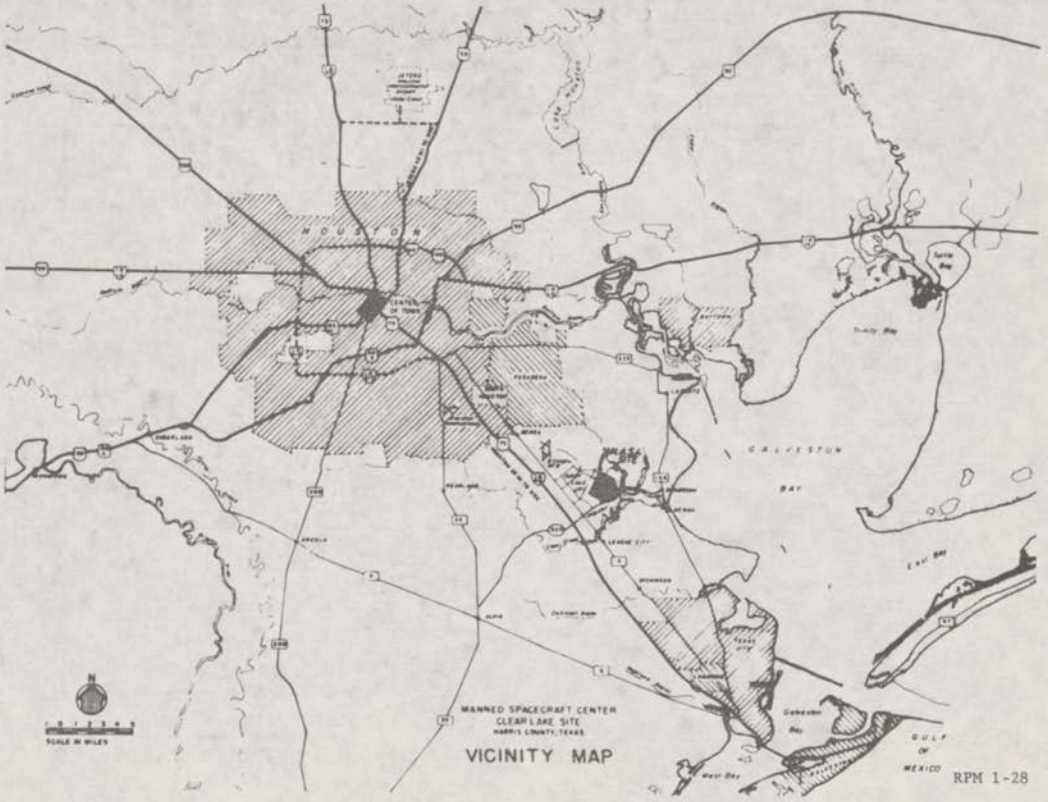
This category covers the cost of local transportation within the JSC area provided by GSA, the JSC share of operating costs at Ellington Air Force Base, and the cost of stenographic services and torts and claims.

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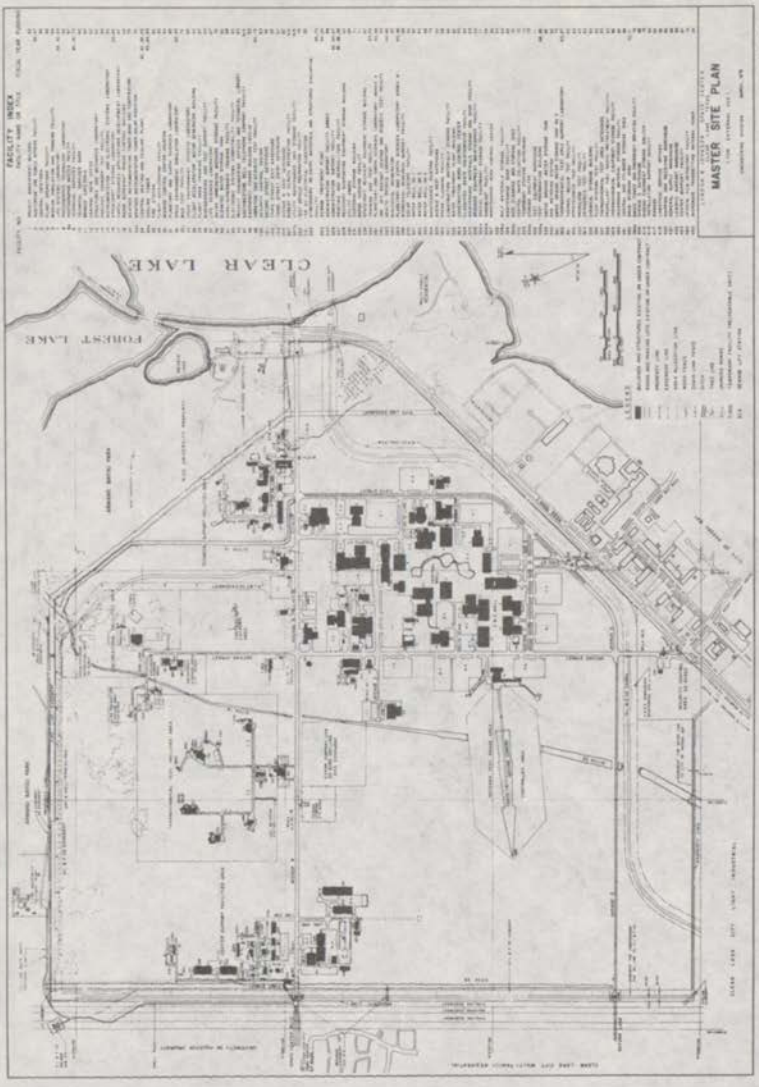
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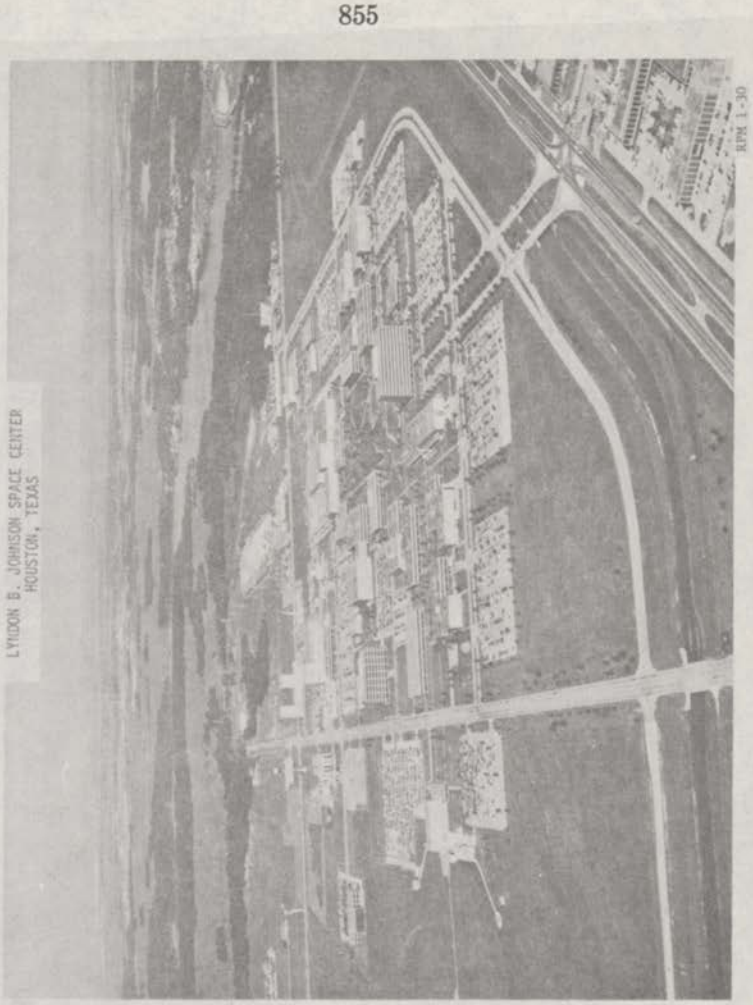


VICINITY MAP

RPM 1-28



RPM 1-29


LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS
KPM 1-30

JOHN F. KENNEDY SPACE CENTER

DESCRIPTION

The John F. Kennedy Space Center is located approximately 50 miles east of Orlando, Florida. The total land and water area occupied by the installation is 139,305 acres. NASA owns 82,943 acres of that total. The remainder is comprised of the Banana River Causeway Easement (271 acres), the Indian River Causeway Easement (296 acres), and Florida-owned submerged lands with Deed of Dedication (55,795 acres).

Expendable launch vehicle operations are conducted at both the Air Force's Eastern Test Range, Cape Canaveral Air Force Station and the Western Test Range at Vandenberg Air Force Base, California, which is located 6 miles west of Lompoc, California. Space Shuttle flights will begin at KSC in 1979 and at Vandenberg in 1983.

The capital investment at the Kennedy Space Center and the Western Test Range, including fixed assets in progress and contractor-held facilities as of September 30, 1978 was $1,329,176,000.

CENTER ROLES AND MISSIONS

The Kennedy Space Center (KSC) was established at Cape Canaveral, Florida, in July 1962 to serve as the primary NASA center for the test, checkout, and launch of space vehicles. This site was chosen because of its unique geographical characteristics, climate, local growth capability, accessibility, and availability. The Center has since grown to become the major Free World launch site with a unique civil service staff of unparalleled expertise in the field of test, checkout, and launch of space vehicles and in the design of associated ground support equipment. The technical facilities developed at KSC represent a recognized national resource. The principal roles are:

Space Transportation System (STS) Ground Operations - includes launch operations, Solid Rocket Booster (SRB) retrieval, STS refurbishment and turnaround, Levels I and II integration, Spacelab Level III and IV integration, integrated logistics and transportation and postlanding operations, and flight line medical and biomedical support.

STS Sustaining Engineering - includes configuration management, operational hardware accommodations and modifications.

Expendable Launch Vehicle Operations - includes launch preparation and checkout for the current inventory of launch vehicles.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
I. Personnel and Related Costs	64,543	66,705	70,123	70,502
II. Travel	2,120	2,338	2,416	2,368
III. Facilities Services	22,023	27,906	26,216	31,421
IV. Technical Services	5,733	6,182	6,444	6,987
V. Management and Operations	19,346	15,300	15,708	16,871
Total, fund requirements	113,765	118,431	120,907	128,149

Distribution of Permanent Positions by Program

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Direct Positions				
Space Transportation Systems	1,625	1,654	1,627	1,624
Space Shuttle	1,224	1,089	1,225	1,146
Space flight operations	218	434	250	342
Expendable launch vehicles	183	131	152	136
Space Science	2	3	2	2
Life sciences	2	3	2	2
Space and Terrestrial Applications	11	17	10	7
Space applications	9	12	9	6
Technology utilization	2	5	1	1
Aeronautics and Space Technology	3	---	2	2
Space research and technology	2	---	1	1
Energy technology	1	---	1	1
Subtotal, direct positions	1,641	1,674	1,641	1,635
Center Management and Operations Support Positions	538	533	552	552
Total, permanent positions	2,179	2,207	2,193	2,187

SPACE SHUTTLE

1,146 Permanent Positions (Civil Service)

The Kennedy Space Center has been assigned the Launch and Landing Project of the Space Shuttle program. Major roles for the accomplishment of this responsibility include launch systems development and ground operations. In the performance of these roles, 1980 will represent a period of continuing activity at KSC in preparation for fully operational shuttle. Orbiter 102 will be used for the first manned orbital flight in late 1979, and preparations will be in progress for three additional orbital test flights during 1980.

Construction of new launch support facilities and modification of existing facilities will be complete with installation and checkout of remaining support equipment in preparation for scheduled flights. Major facilities involved are:

Orbiter Landing Facility (OLF)

The installation and checkout of operational television (OTV) will be completed. This system along with the ground support equipment previously installed will support Shuttle landings after the fourth orbital flight test.

Orbiter Processing Facility (OPF)

Integration and checkout of all ground support systems in the Low Bay Annex and High Bay 2 will continue in preparation to be completed when the second orbiter arrives at KSC in 1981.

Vehicle Assembly Building (VAB)

Modification of support systems and equipment will continue in preparation for the Solid Rocket Boosters and External Tanks as well as full Shuttle integrated operations. Installation and checkout of support equipment in High Bays 1 and 2 will also commence.

Mobile Launcher Platforms (MLP)

Mobile Launcher Platform 1 became operational in 1979 with Mobile Launcher Platform 2 support equipment installation and checkout starting in 1980.

In addition to the activity involving major facilities, KSC will continue the design, acquisition, and installation of equipment to be used in support of the Shuttle. This includes not only that equipment provided

by KSC contractors, but also that to be supplied by the development contractors as part of their flight vehicle contract. KSC will also continue the refurbishment of selected existing support equipment for reuse on the Shuttle program.

A new category of support equipment is the Launch Processing System (LPS). This automated checkout system, conceived and developed by KSC, is a major innovation in the checkout and launch of sophisticated space vehicles. This system will not only provide automated checkout capability for the Shuttle vehicle, but also provide engineering data for operations and management decisions. It will be operational for orbital test flights.

Another major role for KSC in the Shuttle program, in addition to ground system development, is that of ground operations. This includes the test and checkout of each flight element as it arrives at KSC for development flight testing, the integration of the several elements (Orbiter, External Tank, Solid Rocket Booster) into the Shuttle vehicle and integrated testing of the stacked configuration, propellant loading, and launch. Subsequent to landing, KSC will refurbish the Orbiter in preparation for the next mission. Also included is retrieval, disassembly, and refurbishment of the expended solid rocket boosters. Since the initial orbital flight test launches will land at Dryden Flight Research Center (DFRC), provisions will be made for the ferrying of the Orbiter back to KSC (for maintenance and launch).

SPACE FLIGHT OPERATIONS — 342 Permanent Positions (Civil S

860

The conduct of the space flight operations program at KSC includes Spacelab, Inertial Upper Stages, support and multimission support that may be assigned for Shuttle flight operations.

KSC's role in the Spacelab program is similar to that of the Shuttle; that is, KSC is responsible for launch site development and for ground operations. With delivery of the Spacelab engineering model in 1979 and flight equipment in the latter part of 1979, KSC will continue the additional task of analytical engineering. Responsibility for this task of ensuring that the experiments to be mounted on or in the Spacelab are compatible with the Spacelab, with each other, and with safety requirements will transfer to KSC for the third Spacelab mission. The first Spacelab flight unit will be delivered in 1980 with preparations for the first flight in 1981.

The upper stages consist of the Interim Upper Stage (IUS) and the Spinning Solid Upper Stage (SSUS). The IUS and SSUS are expendable, propulsive stages intended for use in the development of Shuttle transported payloads to high energy orbits not attainable by the Shuttle alone.

The Interim Upper Stage (IUS) is being developed by the Air Force and will be operational in 1980. KSC will be responsible for mating the Spacecraft to the IUS. Initial design review of the IUS integration activities will continue in 1980 with the first delivery of hardware in mid-1980.

Under current plans the Spinning Solid Upper Stages (SSUS) will be developed, checked out and mated to a payload by the SSUS commercial developer. KSC will have responsibility for integration of the SSUS and its payload and then into the Shuttle payload bay.

KSC will provide facilities and support to the various payload developers and experimenters during processing at KSC. Thus, KSC, in concert with other NASA organizations must analyze potential payload requirements, identify payload facility capability at KSC, and prepare documentation for potential payload users. Based on experience gained during the Expendable Launch Vehicle program, KSC will monitor the payload activity from conception, participate in design reviews to ensure compatibility with KSC facilities, and provide support coordination during the payload checkout and launch at KSC.

The primary activity in 1980 will be in the integration and checkout of support equipment required in the interfacing of payloads with the STS.

EXPENDABLE LAUNCH VEHICLES — 136 Permanent Positions (Civil Service)

KSC is responsible for the launch preparation and checkout of the current inventory of expendable launch vehicles. This includes the Atlas Centaur and Delta. Launches at both the Eastern Test Range and the Vandenberg Air Force Base are the responsibility of KSC. Eight launches are scheduled for 1980.

LIFE SCIENCES — 2 Permanent Positions (Civil Service)

In 1980 the Kennedy Space Center will continue its support role in the definition, development, and integration of biomedical experiments into Shuttle payloads for life sciences research. These experiments are designed to use the environment of space to accomplish medical and biological research for benefit of man through technological advancement of the state-of-the-art.

SPACE RESEARCH AND TECHNOLOGY — 1 Permanent Position (Civil Service)

The Standards and Practices Program develops equipment for multimission applications and business practices to effect cost savings and for improvements in current and future space programs. In 1980, efforts will continue to manage the development of selected projects.

ENERGY TECHNOLOGY — 1 Permanent Position (Civil Service)

Studies leading to development of technology requirements and the assessment of technology developments on space vehicle launch and landing.

SPACE APPLICATIONS — 6 Permanent Positions (Civil Service)

In the field of applications, KSC will continue in 1980 with resource observation surveys, involving pollution monitoring, and in developing methods of sensing and predicting weather and climatic conditions.

In the area of specialized application tasks, KSC will be performing studies related to requirements, procedures, and techniques of processing space applications payloads for Spacelab.

TECHNOLOGY UTILIZATION — 1 Permanent Position (Civil Service)

The objectives of the Technology Utilization program at KSC are to encourage the use of and to expedite the application of new NASA technology in other sectors, and to impart a better understanding of the technology transfer process and its potential impacts.

CENTER MANAGEMENT AND OPERATIONS SUPPORT — 552 Permanent Positions (Civil Service)

Center Management and Operations Support is defined as the support or services being provided to all Kennedy Space Center organizations which cannot be directly identified to a benefitting program or project. The civil service personnel involved are:

Director and Staff - The Center Director, Deputy Director and the immediate staff, e.g., Legal, Patent Counsel, Equal Opportunity, Public Affairs (includes operation of the Visitors Information Center and its related NASA tours activity), and Safety.

Management Support - Includes a wide range of activity categorized as management support for programs and functional organizations for the entire Center. Specific functions include resource and budget management, program control, contracting and procurement, personnel management, property management, financial management resources control and management information systems and analysis.

Operations Support - This is a broad spectrum of activity that is required to maintain and operate facilities, buildings, and equipment; and to provide the normal housekeeping services and logistics support for the personnel who manage and conduct the affairs of the Center. Specific activities are:

Maintenance and operation of all buildings and facilities
Data processing and computer support

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PERSONNEL AND RELATED COSTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
I. PERSONNEL AND RELATED COSTS	64,543	66,705	70,123	70,502
Basis of Fund Requirement				
A. Compensation and Benefits				
1. Compensation				
a. Permanent positions	57,605	58,836	61,765	62,396
b. Nonpermanent	638	841	1,045	986
c. Reimbursable detailees	157	179	153	26
d. Overtime and other compensation	243	442	397	375
Subtotal, Compensation	58,643	60,298	63,360	63,783
2. Benefits	5,699	5,874	6,230	6,186
Subtotal, Compensation and Benefits	64,342	66,172	69,590	69,969
B. Supporting Costs				
1. Transfer of personnel	99	258	258	258
2. Personnel training	102	275	275	275
Subtotal, Supporting Costs	201	533	533	533
Total, Personnel and Related Costs	64,543	66,705	70,123	70,502

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
A. Compensation and Benefits	64,342	66,172	69,590	69,969
1. Compensation	58,643	60,298	63,360	63,783
a. Permanent positions	57,605	58,836	61,765	62,396

The funds shown above will support 2,187 permanent positions in 1980. Permanent personnel staffing will decrease slightly from 1979 to 1980, but the funding increases in both years is due primarily to the October 1978 pay raise.

Basis of Cost for Permanent Positions

In 1980 the cost of permanent positions will be $62,396,000. The increase results from the following:

Cost of permanent positions in 1979		61,765
Cost increase in 1980		+1,826
Within grade advances and career development:		
Full year effect of 1979 actions	+716	
Partial year effect of 1980 actions	+576	
Full year effect of 1979 pay increase	+68	
Two extra paid days in 1980	+466	
Cost decrease in 1980		-1,195
Turnover savings and abolished positions:		
Full year effect of 1979 actions	-339	
Partial year effect of 1980 actions	-740	
Change in reimbursable activity	-116	
Cost of permanent positions in 1980		62,396

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
b. Nonpermanent positions				
1. Cost	638	841	1,045	986
2. Workyears	71	103	118	113

The 1979 current estimate increases from the 1979 budget estimate due to the implementation of a non-baccalaureate cooperative training program and an experimental part-time program. The 1980 estimate reflects a slight decrease from 1979 as a result of the absorption of the part-time program into the permanent position ceiling. The level of 113 workyears is distributed to the following programs:

Distribution of Nonpermanent Workyears

Programs	Workyears
Cooperative training programs	55
Summer programs	15
Youth opportunity programs	21
Other temporaries	22
Total	113

c. Reimbursable detailees	157	179	153	26

Provides funding for the services of a software applications officer in support of the Shuttle program. The decrease from the 1979 budget estimate to the 1979 current estimate reflects the completion during the year of duty tours for five others detailed from the Department of Defense. The decrease in 1980 reflects the full year effect of these actions.

d. Overtime and other compensation	243	442	397	375

The funding decrease from the 1979 budget estimate to the current estimate is due to the slip in the scheduled launch date for the First Manned Orbital Flight (FMOF) of the Shuttle. This delay allows for less critical scheduling of Shuttle preparation efforts. The decrease from 1979 to 1980 reflects reduced demands for overtime as launch of the STS vehicle moves through the design, development, test and evaluation phase.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
2. Benefits	5,699	5,874	6,230	6,186
Category of Cost:				
Civil Service Retirement Fund	4,050	4,177	4,427	4,425
Employee life insurance	250	266	274	274
Employee health insurance	1,123	1,120	1,211	1,211
Workman's compensation	192	192	197	197
FICA	13	24	26	26
Incentive awards	60	95	95	53
Severence pay	11	---	---	---
Total	5,699	5,874	6,230	6,186

The increase from the 1979 budget estimate to the 1979 current estimate is due primarily to the effect of pay increases. The decrease in 1980 is due to continuing personnel reductions and an increase in reimbursable activity.

B. Supporting Costs	201	533	533	533
1. Transfer of personnel	99	258	258	258

Provides for continuing recruitment and transfer of personnel essential to the KSC Shuttle mission. Funds required for the transfer of personnel in 1980 remain level with 1979. The 1980 estimates provide for 60 relocations at an average of $4,300 each.

2. Personnel training	102	275	275	275

These funds provide the means to maintain proficiency in various skills, to provide the necessary training for those employees with technological expertise to keep abreast of the state-of-the-art in their respective fields, and to meet career development needs. Personnel training costs for 1980 will remain at the 1979 level.

TRAVEL

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
II. TRAVEL	2,120	2,338	2,416	2,368
Basis of Fund Requirements				
A. Program Travel	1,260	1,274	1,308	1,209
B. Scientific and Technical Meeting	16	24	12	12
C. Management and Operations	844	1,040	1,096	1,147
Total, Travel	2,120	2,338	2,416	2,368
A. Program Travel	1,260	1,274	1,308	1,209

Program travel is directly related to the accomplishment of the Center's mission and accounts for 54 percent of the travel budget. Approximately 2,400 trips will be required to carry out the Kennedy Space Center responsibilities in this category. Program travel has reflected the Center's involvement in the design and manufacturing of Shuttle ground system equipment, design and construction of Shuttle facilities, and the activation of systems manufactured at off-site locations. During 1980, our effort will be to test, checkout, and launch the Orbiter. Travel to Dryden Flight Research Center, the landing site of the orbital flight tests will be required.

The reduction from 1979 to 1980 reflects the completion of the major portion of travel to Shuttle development centers and manufacturers' sites which was necessary to assure operations capability of all systems for which KSC is responsible.

B. Scientific and Technical Meeting	16	24	12	12

Scientific and technical meeting travel permits employees to participate in meetings and technical seminars with other representatives of the aerospace community. This participation allows them to benefit from exposure

to technological advances outside KSC, as well as to present both accomplishments and problems to their associates. Many of the meetings are working panels convened to solve certain problems for the benefit of the Government. It is planned that 1980 travel for this category will be the same as 1979.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
C. Management and Operations	844	1,040	1,096	1,147

Management and operations travel is used for the direction and coordination of general management matters. It includes travel in such areas as personnel, financial management and procurement activities; travel of the Center's top management to NASA Headquarters, and other NASA centers; and local transportation. Approximately 800 trips are planned for 1980. The increases in both 1979 and 1980 are due to increased requirements for local travel brought about by the increased on-site population for Shuttle preparations.

FACILITIES SERVICES

Kennedy Space Center (KSC) is located on 139,305 acres and has a complex of facilities which are mainly made up of test and office type buildings as well as launch operations facilities. This complex encompasses 5,297,528 gross square feet of building space, including 13 major buildings. Also included are 14 major technical facilities. This plant supports an average daily on-Center population of about 8,500 personnel. Many of the test facilities are utilized during off-peak hours or on more than one shift. A substantial increase in services is required to meet the needs of Shuttle support activities. The budget estimate also includes plant needs at its component installation on Vandenberg Air Force Base.

III. FACILITIES SERVICES	22,023	27,906	26,216	31,421
Basis of Fund Requirements				
A. Rental of Real Property	1	10	110	110
B. Maintenance and Related Services				
1. Facilities	4,571	7,343	5,519	6,841
2. Equipment	575	603	630	847
Subtotal	5,146	7,946	6,149	7,688

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
C. Custodial Services	9,287	10,299	10,147	12,450
D. Utility Services	7,589	9,651	9,810	11,173
Total, Facilities Services	22,023	27,906	26,216	31,421
A. Rental of Real Property	1	10	110	110

This provides for the rental of off-site facilities for news and reception center activities associated with launches and major public events. The increase from the 1979 budget estimate reflects the needs of the Shuttle launch activities, including the first manned orbital flight (FMOF) test of the Space Shuttle. Many of these requirements were unforeseen at the time of the 1979

B. Maintenance and Related Services	5,146	7,946	6,149	7,688
1. Facilities	4,571	7,343	5,519	6,841

This activity involves the operations and maintenance of applicable facilities at KSC, Cape Canaveral Air Force Station, and Vandenberg Air Force Base. The size, complexity and wide geographical dispersion of these facilities places heavy demands on facilities services. The decrease from the 1979 budget estimate to the 1979 current estimate is due to the deferral into 1980 of facility projects in support of Space Shuttle activities. The increase in 1980 over 1979 reflects this shift and is consistent with Shuttle program schedules.

a. Maintenance and operation of facilities (145 workyears)..... 3,982

This activity includes, in addition to the normal activities associated with facility maintenance or management of direct maintenance personnel, the responsibilities for space utilization, utility rate study and analysis as well as corrosion control and cathodic protection activities.

In addition, there are minor facility related services for such items as payment of certification fees for facility maintenance at Vandenberg Air Force Base, and internal moves of personnel and related plant rearrangements.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		

b. Ground maintenance (29 workyears of effort)..... 840

This involves the provision of grounds maintenance and related supplies and equipment and reimbursement to the Air Force for the maintenance of NASA facilities at Cape Canaveral Air Force Station.

c. Facilities design engineering (36 workyears of effort)..... 1,004

This effort involves inspecting, siting, and other engineering functions associated with institutional facilities.

d. Supplies and facilities equipment.....

Funds provide building materials, hardware, metals, plumbing supplies, electrical materia general maintenance and operating materials.

e. Routine facilities work..... 366

Minor construction, repair, and alteration projects are included in this activity. A level of effort of 13 workyears is provided by a support contract with off-site contractors being brought in when needed.

2. Equipment.....	575	603	630	847

This funding provides for 17 workyears of support contractor effort and related supplies and equipment required for maintenance and repair of heavy equipment items. The 1980 estimate reflects equipment purchases and maintenance to support increasing operational activity.

C. Custodial Services.....	9,287	10,299	10,147	12,450

The demand for these services will increase especially for janitorial, fire protection, and security services in 1980 as the Space Shuttle program reaches the orbital flight test stage. The increase from 1979 to 1980 is due to negotiated support contract wage increase and additional workyears of effort to support shuttle operations.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
1. Janitorial services (117 workyears)				2,420

This activity provides janitorial services to some 2.0 million square feet of KSC floor areas, including highly specialized services to cleanroom areas.

2. Fire protection services (108 workyears)				3,416

This activity will provide for fire protection service for KSC property and personnel including:

a. Support of increasing hazardous tests and operations and orbiter landings.
b. Performing fire drills and fire inspections of facilities and equipment.
c. Providing fire protection instructions.
d. Fighting fires.

This estimate reflects the full activation of both KSC fire station for Shuttle operations.

3. Security services (205 workyears)				5,341

This activity includes the protection of personnel and property at KSC and involves:

a. Support of increasing hazardous tests and operations.
b. Badging of all on-site personnel and official visitors.
c. Safeguarding flight hardware and other items of high intrinsic value arriving for OFT.
d. Protecting classified information.
e. Maintaining area and traffic control.

4. Other related activities				1,273

These activities are as follows:

a. Janitorial services and security services reimbursed to the Air Force performed on NASA facilities at Cape Canaveral Air Force Station.

b. Pest control services for KSC which involves five workyears of support contractor effort.

c. Laundry services at both KSC and Vandenberg Air Force Base.

d. Provision of supplies and equipment related to custodial services.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
D. Utilities Services	7,589	9,651	9,810	11,173

The major utility service at KSC is electrical energy purchased from the Florida Power and Light Company through an Air Force contract. Fuel oil is purchased from a local supplier. Steam service is provided by the Air Force at Cape Canaveral Air Force Station. Water services are purchased from the City of Cocoa and sewage treatment is accomplished on-site.

At Vandenverg Air Force Base, utility services are purchased through the U.S. Air Force.

Utility plant operations and maintenance and utility distribution systems maintenance are provided in this activity which also covers reimbursement to the Air Force at the Eastern Test Range (ETR) and Vandenberg Air Force Base for these services. These services involve 81 workyears of support contractor effort. The commodity costs are as follows:

1. Electricity (199,400 MW/Hrs.)	7,218
2. Fuel oil (2,200,000 gals.)	994
3. Steam (47,800 K lbs.)	253
4. Water and sewage	60
5. Vandenberg AFB - all utilities	147

The increase from the 1979 budget to the current estimate is a reduction in electricity and fuel oil costs offset by the addition of six support contractor workyears for increasing activity in STS related facilities. The 1980 increase is due to greater electricity consumption for test, checkout, and launch activity, higher utility rates, and negotiated support contract wage increases. Contractor workyears are level.

TECHNICAL SERVICES

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
IV. TECHNICAL SERVICES	5,733	6,182	6,444	6,987
Basis of Fund Requirement				
A. Automatic Data Processing				
1. Equipment	411	509	430	464
2. Operations	2,999	2,758	3,296	3,456
Subtotal	3,410	3,267	3,726	3,920
B. Scientific and Technical Information				
1. Library	342	327	349	377
2. Education and information	1,643	1,750	2,018	2,311
Subtotal	1,985	2,077	2,367	2,688
C. Shop Support and Services	338	838	351	379
Total, Technical Services	5,733	6,182	6,444	6,987
A. Automatic Data Processing	3,410	3,267	3,726	3,920

These funds provide for the cost of general management ADP programs including the lease, purchase, and maintenance of ADP equipment and programming and operations services.

1. Equipment	411	509	430	464

The funding provides for the maintenance and lease of the Honeywell 635 and supporting equipment. The decrease from the 1979 budget to the current estimate is due to deferred equipment purchases. Increase in 1980 is due to increased costs for the same level of services.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
2. Operations	2,999	2,758	3,296	3,456

One hundred and twenty-three support contractor workyears provide programming services for payroll, general accounting, supply reports, procurement, contract reports, technical support information retrieval (failure analysis), preventive maintenance reports of control vehicle components and ground support equipment, contract surveillance status reports for the KSC Personnel Office, security reports, and resources and financial management reports.

The increase from the 1979 budget estimate to the 1979 current estimate is due to 17 additional workyears primarily for programming support to the financial management system update for the STS operation period. The 1980 increase is due to negotiated support contract wage increases partially offset by a reduction of five workyears as programming the financial management system nears completion.

B. Scientific and Technical Information	1,985	2,077	2,367	2,688

The funding provides for operation of a technical library at KSC and for various technical and administrative documentation services throughout the center, including support to Public Affairs' educational and information program.

1. Library	342	327	349	377

Fourteen support contract workyears are required to operate the KSC library facilities. The cost includes technical reports and literature in hard copy and microfiche; scientific technical and management books and periodicals; military, federal, and professional society specifications and standards are also included. The contractor also operates a Shuttle/Spacelab documents repository which catalogs, classifies, and indexes documents for storage and retrieval; and provides document reference and distribution services. This category also includes supplies used by the contractor. The increase from the 1979 budget to the 1979 current estimate is due to higher costs for books and periodicals. In 1980, the increase is due to wage increases; workyears are level.

2. Education and information	1,643	1,750	2,018	2,311

The funding provides for 66 support contractor workyears to prepare publications pertaining to the receipt, checkout, and launch of space vehicles; Shuttle/Spacelab activities, design engineering functions,

and institutional support. Subject matter covers tracking, facilities modifications, booster recovery, earth resources, future programs, launch processing, vehicle tests checkout operations, safety procedures, materials analysis, radiological controls, and contingency plans.

Public Affairs support provides for the gathering and dissemination of information about the agency's programs to the mass communications media, the general public, and to the educational community at the elementary and secondary levels. It also includes photographic support at Vandenberg Air Force Base, which is primarily for Public Affairs activities. The increase from the 1979 budget to the current estimate is primarily to support Public Affairs activities related to initial Shuttle launch activities some of which were unforeseen at the time of the 1979 budget. Increase in 1980 is due to four additional workyears for increasing Shuttle launch activities.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
C. Shop Support and Services	338	838	351	379

The funds provide for a support contractor to perform technical support services such as exercising coordinative control of support activities to assure a constant state of readiness to support test/launch operations. Includes disaster and hurricane planning performed on a center-wide basis through coordination with the KSC Emergency Preparedness Officer (two workyears); training of all KSC personnel engaged in hazardous occupations (five workyears); and a wide variety of shop services, primarily fabrication of non-integral institutional equipment used throughout center facilities (six workyears).

The decrease from the 1979 budget estimate is a result of a decrease of 17 support contractor workyears due to a partial reclassification of fabrication effort to facilities services. Changes in contractor structure resulted from recompetition efforts.

MANAGEMENT AND OPERATIONS

V. MANAGEMENT AND OPERATIONS	19,346	15,300	15,708	16,871
Basis of Fund Requirements				
A. Administrative Communications	2,332	2,351	2,333	2,359
B. Printing and Reproduction	3,737	3,246	3,468	3,706

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
C. Transportation	3,193	2,941	2,293	2,735
D. Installation Common Services	10,084	6,762	7,614	8,071
Total, Management and Operations	19,346	15,300	15,708	16,871
A. Administrative Communications	2,332	2,351	2,333	2,359

Funds provide for the costs of local telephone service, Federal Telecommunications System (FTS), long distance tolls, and teletype services in support of all NASA personnel, contractor and civil service, located on the Kennedy Space Center, the Cape Canaveral Air Force Station, and Vandenberg Air Force Base. Costs remain essentially level from year to year.

1. Local telephone service 1,673

Provides for the total KSC population, including contractors, and includes the administrative telephone switchboard, single line telephones for special areas, telephones accoustically coupled for data transmission, and local exchange lines for Brevard and Orange County locations.

2. Long distance telephone service 662

NASA contractors and other institutions who conduct official business with KSC are widely dispersed throughout the United States. KSC utilizes FTS and other leased lines to minimize costs. Service is provided to authorized users, including on-site contractors. Paid long distance and GSA leased lines are in this category.

3. Non-telephone communications 24

Provides specialized services such as teletype and wire news services. In addition, the lease and maintenance of various small electrical/electronic systems such as printers which support major communication systems are included.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
B. Printing and Reproduction	3,737	3,246	3,468	3,706

Includes the printing of test and checkout procedures, launch countdowns, microfilming, engineering drawings, telemetry data, and other related technical material.

The estimate for administrative printing includes long lead time items such as forms production and minor efforts, such as the KSC house organ, and miscellaneous special requirements for duplicating, photostating, blueprinting, microfilming, and other photographic reproductions. Services are performed by other government agencies or by commercial printing firms. The support contractor is being increased 10 workyears from the 1979 budget estimate to cover the increasingly heavy demand of STS activities in preparation for arriving hardware and FMOF. The increase in 1980 is due to support contractor wage rates; workyears are level.

1. Scientific and technical printing..... 2,825

Eighty-seven workyears of support contractor effort are required to print or reproduce an average of 7.4 million units per month. Supplies used by the contractor and replacement equipment are included in this category.

2. Administrative printing..... 269

This estimate includes the cost of services provided by the Government Printing Office, Patrick Air Force Base, and Vandenberg Air Force Base.

3. Office copiers..... 612

Provides office copier service to the total on-site population, civil service and contractor. Copiers are located in central service centers and individual offices where workload justifies assignment. This arrangement has proven to be an economical way of providing this service.

C. Transportation	3,193	2,941	2,293	2,735

The center provides a centralized motor pool, operated by GSA, for civil service and support contractor personnel. The movement of supplies and equipment by commercial carrier are included in this area. This category also includes the operation of heavy equipment, and related supplies and materials, and aircraft

operations. Decrease from the 1979 budget from the current estimate reflects a greater shift in transportation management to program areas (15 support contractor workyears) than planned. The increase in 1980 is due to wages on support contracts; workyears are level. An increase of 400,000 miles is planned for GSA trucks to meet on-site STS contractors' needs for work vehicles.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
1. Truck rental				1,531

Provides for 545 cargo-type vehicles. This is an increase of 115 vehicles over the 1979 budget estimate to provide for the STS contractors mentioned above.

2. Common carrier and related services				709

Eight support contractor workyears are required to perform the transportation management functions, which include coordination, check, inspection, and document control of all shipments and delivery of in-bound shipments. The balance of this requirement is supplies used by the support contractor, minor contracts for off-site packing and crating services, landing fees, maintenance and repair, and supplies and equipment associated with the administrative aircraft.

3. Heavy equipment				495

Twelve workyears of support contractor effort are required to operate KSC-owned heavy equipment, such as tractors, cranes, trailers, and trucks. The balance is for supplies.

D. Installation Common Services	10,084	6,762	7,614	8,071

The funds provide for logistics services, mail and distribution services, medical services, Center management and staff activities, and a wide variety of minor contracts for special and one-time services. The increase in 1979 over the 1979 budget estimate reflects a 40 workyear increase in supply management, medical support, and mail services to support the increasing Shuttle workload. The increase in 1980 is due to negotiated contract wage increases.

1. Center management and staff functions				103

This category includes tort claims, notary public fees, court reporting costs, patent counsel representation, and equal opportunity activities.

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	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
2. Medical services				1,464

Two major types of medical service are provided, occupational medicine and environmental health.

a. Occupational medicine				1,237

Forty-nine workyears of support contractor effort are required to provide emergency and first aid care for the KSC workforce, guests, and tour visitors; health maintenance and counseling for civil service employees; and a variety of physical examinations and special programs for health maintenance, applied research, and job certification for civil service and contractor personnel. The contractor has also been charged with Occupational Safety and Health Administration standards compliance for all KSC elements. The medical program operates on a three-shift basis to provide emergency and ambulance services and special standby service in support of hazardous tests and operations. This category also covers supplies and equipment used by the contractor and a minor contract at Vandenberg Air Force Base, primarily for physical examinations at that location.

b. Environmental health				227

Includes industrial hygiene, radiological health, and environmental sanitation requiring eight workyears of support contractor effort. This includes water supply and distribution, sewage treatment and disposal, treatment and disposal of industrial wastes, solid waste management and disposal, selection and use of pesticides, and the surveillance of operations producing atmospheric, water, or soil pollution.

3. Installation support services				6,504
a. Supply services				4,251

These funds provide 153 support contractor workyears needed to provide a broad range of logistics services including receipt, storage, and issue of supplies and equipment, as well as maintaining various management systems.

b. Mail				717

Mail and distribution services of 34 workyears, provided by a support contractor, include distribution of inter-office mail, classified document control, operation of the KSC branch post office, and postage.

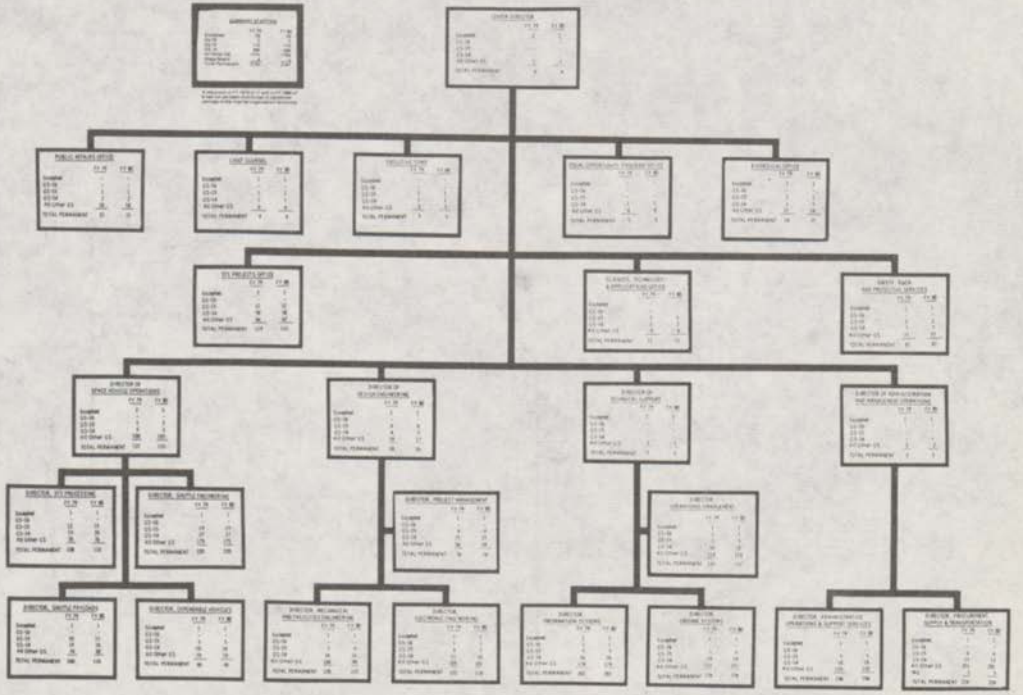
	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
c. Office supplies				839

As an economy measure, KSC provides common support to the total population, civil service and contractor. This category includes a wide variety of office supplies and materials.

d. Administrative equipment				697

This category covers lease, maintenance, and purchase of administrative equipment. Rentals are primarily special purpose office equipment more economical to lease than purchase, maintenance is provided for all government-owned administrative equipment in active service, and purchases are largely replacements of office machines such as typewriters and calculators.

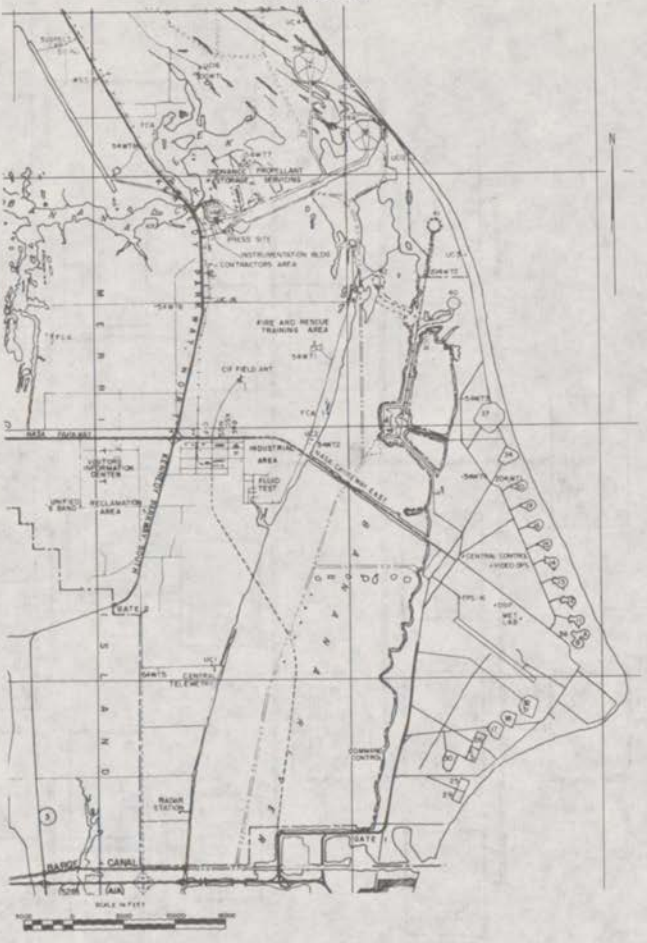
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
JOHN F. KENNEDY SPACE CENTER



RPM 2-26

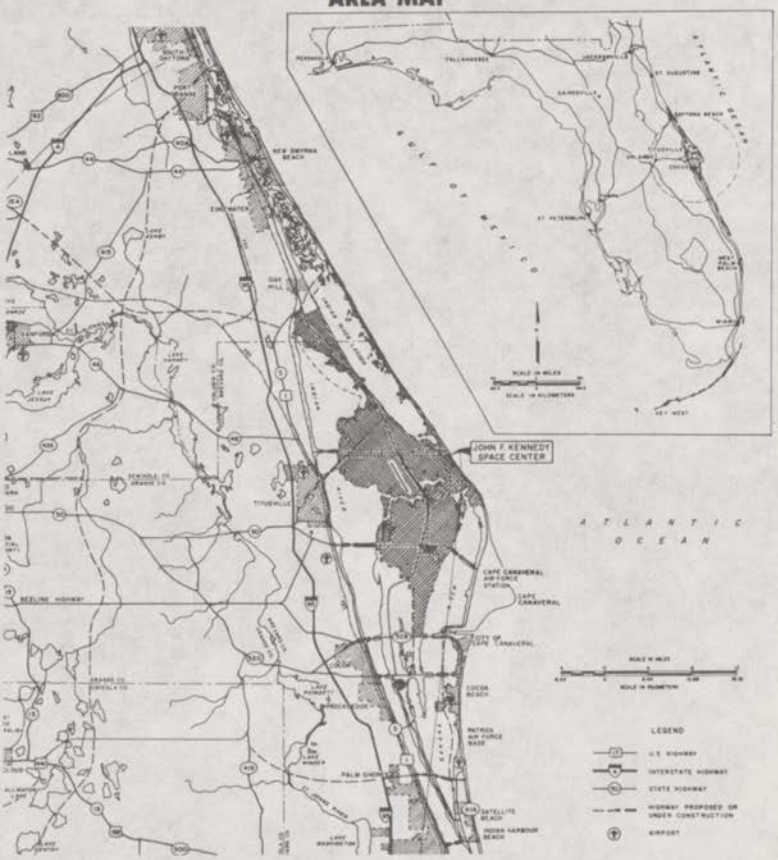
JOHN F. KENNEDY SPACE CENTER, NASA
FISCAL YEAR 1980 ESTIMATES
LOCATION PLAN

RPM 2-27

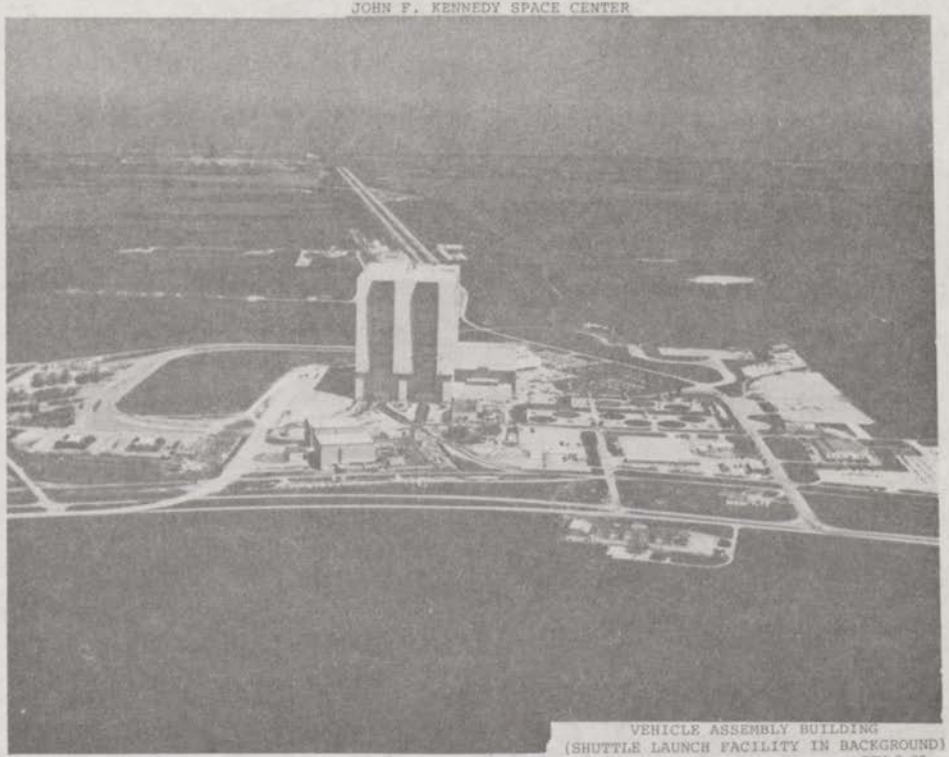


JOHN F. KENNEDY SPACE CENTER, NASA
FISCAL YEAR 1980 ESTIMATES
AREA MAP

RPM 2-28

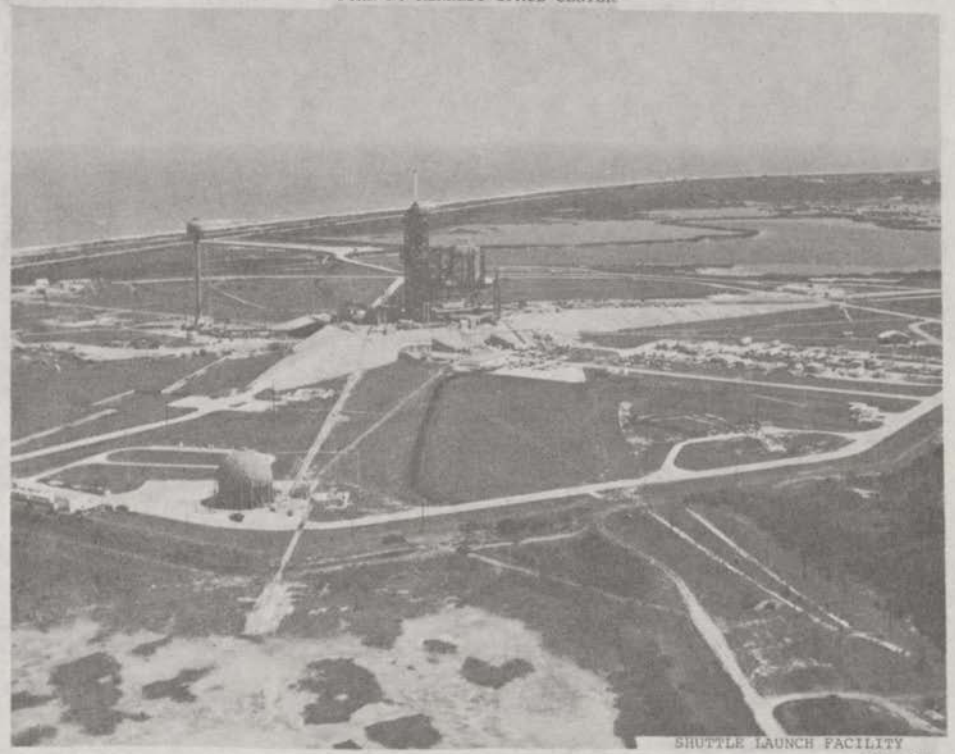


JOHN F. KENNEDY SPACE CENTER



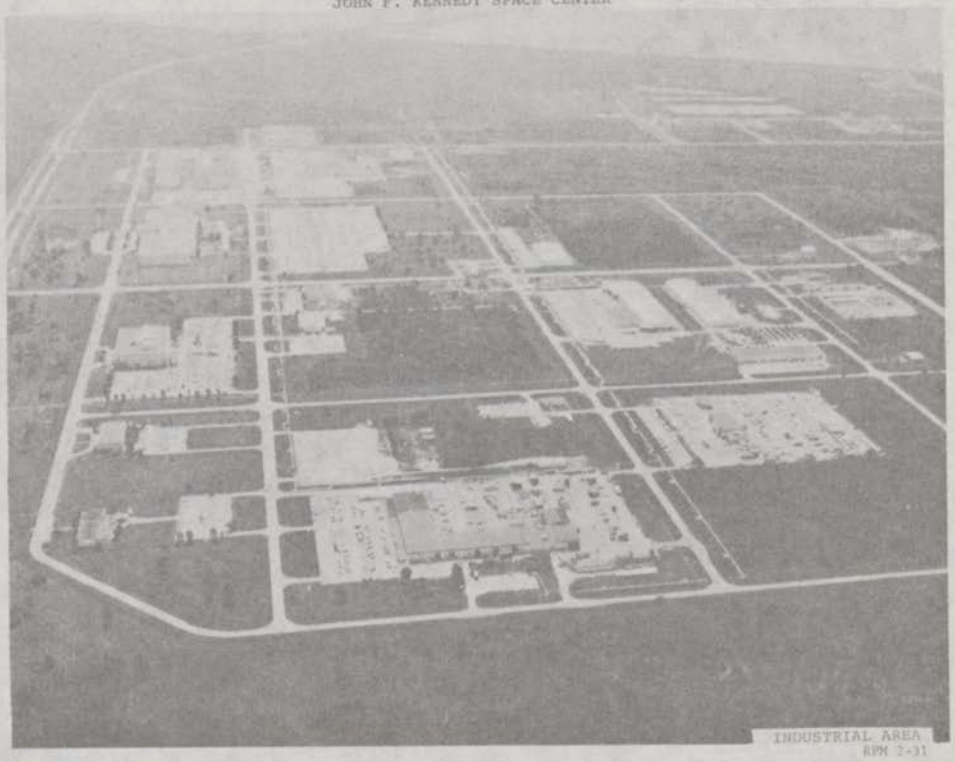
VEHICLE ASSEMBLY BUILDING
(SHUTTLE LAUNCH FACILITY IN BACKGROUND)
RPM 2-29

JOHN F. KENNEDY SPACE CENTER



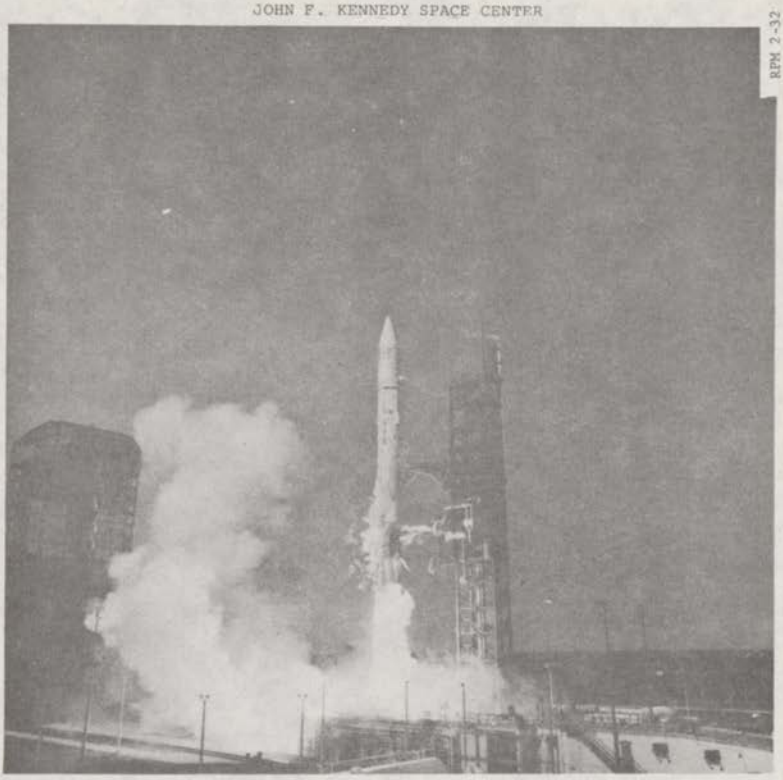
SHUTTLE LAUNCH FACILITY
KPN 2-30

JOHN F. KENNEDY SPACE CENTER



INDUSTRIAL AREA
KPN 2-31

JOHN F. KENNEDY SPACE CENTER



RPM 2-32

ATLAS CENTAUR LIFT-OFF

JOHN F. KENNEDY SPACE CENTER



ARTIST CONCEPT - ORBITER
PROCESSING FACILITY (OPF)

RPM 2-33

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1980 ESTIMATES

GEORGE C. MARSHALL SPACE FLIGHT CENTER

DESCRIPTION

Operations at the Marshall Space Flight Center (MSFC) are conducted at three primary locations:

The principal MSFC site is near Huntsville, Alabama, on Army property at the Redstone Arsenal. The Center occupies 1,841 acres under a nonrevocable use permit from the Army. Certain facilities such as the Redstone Arsenal Air Field and some utilities are used jointly by NASA and the Army. The Huntsville location is connected by deep water access to its component Michoud Assembly Facility via the Tennessee, Ohio, and Mississippi Rivers.

The Michoud Assembly Facility is located 15 miles east of New Orleans, Louisiana, where the External Tank for the Space Shuttle is being produced and where activities for other Federal agencies are conducted. The Michoud Facility occupies 832 acres and provides 3,557,331 gross square feet of space, including the main assembly plant which has an area of 43 acres under one roof. The facility is located on the Gulf Intracoastal Waterway and has deep water access via the Mississippi River.

The Slidell Computer Complex, located at Slidell, Louisiana, 20 miles northeast of the Michoud Assembly Facility, occupies 14 acres and provides centralized computer services for MSFC, Michoud, the National Space Technology Laboratories, other NASA centers, and associated contractors, as well as other Government agencies as designated.

A number of the individual facilities at MSFC and its component installations are unique within NASA, the Nation, and the rest of the free world. The combined capability of the science and engineering laboratories, special development facilities, and test facilities, provide a unique national resource for the designing, developing, and testing of complex space systems. The total capital investment of the Marshall Space Flight Center and its installations in Louisiana, including fixed assets in progress, and contractor-held facilities at various locations as of September 30, 1978, was $1,006,068,000.

CENTER ROLES AND MISSIONS

The Marshall Space Flight Center serves as one of NASA's primary centers for the design and development of space transportation systems, orbital systems, scientific and applications payloads, and other systems for present and future space exploration. MSFC is the principal center within NASA for rocket propulsion systems; for the design and development of manned vehicle systems; for Spacelab mission management and payload definition; for design and development of large, complex, and specialized automated spacecraft; and development of the space processing activity base. MSFC is a primary center within NASA for the development and processing of science and applications experiments and for the conduct of energy-related system studies. In addition, MSFC conducts a vigorous research and technology program and is deeply involved in the study and definition of future programs, including significant roles contributing to the development of large, complex space structures, space propulsion systems, materials engineering, materials processing in space, power systems, guidance and control, fundamental electronics, and payload systems analysis and integration.

In addition to onsite activities at Huntsville, Alabama, MSFC manages the Michoud Assembly Facility at New Orleans and the Computer Complex at Slidell, Louisiana. Resident offices are maintained at other centers and in conjunction with major industrial sites in various locations throughout the Nation, and in Europe for the Spacelab program. The principal and supporting roles are:

PRINCIPAL

Propulsion Systems - design, development and procurement of major propulsion-oriented systems and subsystems. Current focus is on Shuttle-related systems, including Shuttle main engine, solid rocket booster, external tank, and inertial upper stage in cooperation with the Air Force. Advanced program effort includes the solar electric propulsion systems, the heavy lift launch vehicle, and the orbital transfer vehicle.

Manned Space Vehicle Development - design, development and procurement of manned vehicle systems.

Spacelab - focus is on systems engineering management, development interface with European Space Agency and procurement.

Advanced Studies - focus is on orbital systems and advanced transportation systems.

Advanced Development - technology advances focused on the advanced missions identified above.

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Space Transportation System (STS) Sustaining Engineering - provide sustaining engineering for STS hardware.

Spacelab Mission Management and Payload Definition - management of Spacelab I and II missions and definition of requirements for and development of an Atmospheric Cloud Physics Laboratory for flight as a partial payload of the Spacelab.

Specialized Automated Spacecraft - design and development of large, complex and/or specialized automated spacecraft as assigned. Current focus is on spacecraft systems and experiment integration for Space Telescope and High Energy Astronomy Observatory, and on Gravity Probe B spacecraft studies.

Space Processing - developing space processing discipline base, developing and managing space processing experiments for Spacelab.

Data Management - development of applications-oriented data management discipline base. Contribute to the overall data management systems expertize in support of advanced high data rate systems development.

SUPPORTING

Space Vehicle Structures and Materials - contribute to the development of large, complex space vehicle structures and materials technology base.

Energy Technology - conduct energy-related system studies for reimbursable activity with primary focus on solar heating and cooling and advanced coal extraction technology.

Satellite Power System - conduct definition activity roles.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
I. Personnel and Related Costs	115,638	114,413	120,323	119,961
II. Travel	2,326	2,382	2,492	2,684
III. Facilities Services	11,775	10,598	11,849	12,395
IV. Technical Services	5,636	6,418	5,728	5,588
V. Management and Operations	8,070	7,046	7,884	8,256
Total, fund requirements	143,445	140,857	148,276	148,884

Distribution of Permanent Positions by Program

Direct Positions				
Space Transportation Systems	2,063	2,045	1,876	1,859
Space shuttle	1,610	1,125	1,363	1,171
Space flight operations	453	920	513	688
Space Science	500	558	517	476
Physics and astronomy	500	558	517	476

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Space and Terrestrial Applications	287	281	394	401
Space applications	274	271	382	390
Technology utilization	13	10	12	11
Aeronautics and Space Technology	271	213	222	214
Aeronautical research and technology	9	8	9	9
Space research and technology	94	86	94	94
Energy technology	168	119	119	111
Subtotal, direct positions	3,121	3,097	3,009	2,950
Center Management and Operations Support Positions	639	618	627	611
Total, permanent positions	3,760	3,715	3,636	3,561

PROGRAM DESCRIPTION

SPACE SHUTTLE

1,171 Permanent Positions (Civil Service)

The major MSFC Shuttle element assignments consist of: (1) the Space Shuttle Main Engine (SSME); (2) the Solid Rocket Booster (SRB); (3) the External Tank (ET); (4) planning, preparing and conducting major Shuttle systems tests; and (5) Shuttle system level analysis, test and integration tasks such as: ascent control and stability analysis; flight performance analysis and predictions; aerothermodynamic and acoustic analysis and flight predictions; structural dynamic analysis and modeling; systems safety and risk analysis; and test, checkout and launch criteria requirements.

In 1980 the major emphasis will be shifting from development and ground testing to flight testing and design refinement. The First Manned Orbital Flight or Orbital Flight Test (OFT) #1 is scheduled for late 1979 with three OFT flights scheduled in 1980. Significant effort will be required to provide flight hardware and to evaluate hardware and system performance for these early flights. Additional effort will be required to increase manufacturing/tooling capacity to provide production rate capability to support the current Shuttle Mission Model.

Some current test activities that will continue in 1980 are: (1) main engine system level testing at the National Space Technology Laboratories (NSTL) and at the Santa Susana Facility to provide final flight certification in 1980 and to demonstrate the engine flight life. (2) the SSME Control Simulation Laboratory in the Systems Dynamic Laboratory will continue in operation to assist in flight planning and to investigate system failure modes and anomalies which may occur during OFT. (3) the Main Propulsion Test (MPT) Program at NSTL will be completed early in 1980 but the test facility/capability will be maintained through 1980 to provide backup support to resolve problems which may occur during OFT. Refurbishment requirements for the main engine will be finalized in preparation for the overhaul of the three engines used in the MPT. SRB refurbishment design and procedures will be verified during OFT to assure meeting the design reuse goals. Refinements in design will be pursued to reduce cost per flight, reduce weight, improve producibility, and improve overall Shuttle system performance. Continuing efforts in configuration management, interface control documentation, logistics, and ground operations will require significant effort in 1980. Support will be provided to the Air Force for activation of the Western Test Range.

SPACE FLIGHT OPERATIONS — 688 Permanent Positions (Civil Service)

The Space Flight Operations program includes Space Transportation System Operations; Space Transportation System Operations Capability Development; Development, Test and Mission Support; and Advanced Programs. The STS Operations Capability Development activity includes two major areas of effort: Spacelab, and STS Upper Stages. The Civil Service positions in 1980 are required to carry out the following program milestones:

STS Operations

The STS Operations is the major element of Space Flight Operations. The first operational flight is scheduled for early 1981. During 1980 the activities will include the acquisition of hardware components and production of fligth hardware. Typical functions will be production engineering, design, sustaining engineering, anomaly resolution, logistics and contract monitoring. Space Transportation System Operations activity in 1980 also includes the procurement of Inertial Upper Stage flight hardware and ground support items in preparation for STS operational flights commencing in 1981.

Spacelab

In 1980, the Spacelab Engineering Model and Flight Unit will complete integration and testing in Europe and be delivered to NASA where integration and operational flow process verification will begin. NASA funded hardware and software activity will also be continued. Manufacturing and testing of the Spacelab Transfer Tunnel are scheduled for completion with delivery near the end of the fiscal year, and the Experiment Computer Operating System will reach operational status. Buildup, test, verification, integration and launch of the upgraded engineering model pallet to be flown on some of the Shuttle OFT missions will occur as will similar

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activities for the second upgraded pallet. Activities supporting procurement of additional Spacelab flight hardware will be well underway with some hardware deliveries scheduled to begin during the period and experiment installation and integration and checkout will be in process for Spacelab Mission 1.

In 1980 activities include continuation of program management, systems requirements, and interface definition and control, NASA hardware and software development, and preparation for Spacelab ground and flight verification on a schedule consistent with the milestones for Spacelab operational capability development, which includes the first two Spacelab flights. The primary objectives of these flights, scheduled for 1981 and 1982, are to verify the Spacelab system and subsystems performance capabilities, verify Spacelab/Orbiter and Spacelab/experiment interface compatibility and to determine the Spacelab induced environment.

STS Upper Stages (Inertial Upper Stage - IUS)

MSFC is responsible for the definition and control of the NASA and non-DOD requirements and for providing these to SAMSO for incorporation into the IUS system development contract. In addition, MSFC participating with SMASO, will provide the management and technical evaluation of the IUS development contractor's design, development and test efforts to assure that the NASA-unique and non-DOD user requirements are incorporated.

In 1980, the NASA-unique Inertial Upper Stage (IUS) development activities will include the following: the completion of the NASA Critical Design Review; completion of the drawing release; completion of the su' qualification tests; and preparation for the Twin/Spin vehicle/Airborne Support Equipment structural qualification testing. During this same period, the fabrication and final assembly of four NASA Two- vehicles and one Twin/Spin vehicle will be in process. The first NASA Two-Stage vehicle delivery is s for late 1980.

Advanced Programs

The Advanced Programs effort at MSFC includes the definition and implementation of in-house and contracted system studies to establish the fundamental planning and decision making data needed prior to proposing future space programs. Major 1980 advanced studies activities include: 25KW Power System, Solar Electric Propulsion Stage, fabrication of structural elements in space; studies of improved propulsion systems capable of using different propellants in the same system; continue concept studies of geostationary structures and materials experimentation carriers/modules; and studies of advanced manipulator systems, remote controls, visual aids and sensory systems to augment the ability of humans to function efficiently in space.

PHYSICS AND ASTRONOMY — 476 Permanent Positions (Civil Service)

The Center provides leadership in NASA's Space Science program for the High Energy Astronomy Observatory (HEAO), Space Telescope, and Spacelab Payload Missions 1 and 2; and provides supporting research and technology support to identify the new technologies required for future missions.

High Energy Astronomy Observatory (HEAO)

The High Energy Astronomy Observatory (HEAO) program is a series of three, large unmanned observatories developed under the direction of MSFC for performing scientific investigations in hgih energy astronomy. During 1980, the principal effort will be completing the baseline HEAO-2 mission and conducting the HEAO-C baseline mission. Data reduction and analysis of HEAO-2 and -C data will also be underway during this period, along with management of the HEAO Guest Investigator program and the extended HEAO program involving analysis of data from the extended HEAO-1 mission, and planning and accomplishment of HEAO-2 and HEAO-C extension.

Space Telescope

The objective of the Space Telescope project is to put into orbit via the Space Shuttle a high optical quality 2.4-meter telescope system in late 1983 for use by the astronomical community in conjunction with NASA. MSFC is the lead center for the management of the Space Telescope project and has overall implementation responsibility to the OSS Program Manager for meeting cost, schedule, and technical performance of the project. MSFC is responsible for directing all NASA and contractor's efforts, for establishing and maintaining effective project management activities, and for preparing and maintaining the detailed technical specifications which will define the requirements for all elements of the project. This includes the technical assessment and evaluation of contracted activities for system engineering, design and development, and assembly and verification. In 1980, detail design and development testing will proceed on all hardware elements of the Space Telescope program. During 1980, Critical Design Reviews (CDR's) to assure that the detail design is in accordance with the specifications, will be accomplished on the scientific instruments, the Optical Telescope Assembly, and the Support Systems Module. Detail design of flight hardware will be released for manufacturing in 1980.

Spacelab Payload Mission Management

MSFC is the lead center for the management and implementation of Spacelab Missions 1 and 2 payloads. During 1980, MSFC will continue to manage development of the experiment complements of Spacelab Missions 1 and 2, which will be launched in 1981 and 1982. Supporting mission-peculiar hardware and software will be procured and tested in preparation for the Level IV integration of the mission experiments beginning in 1980. During 1980, interfaces will continue to be maintained with the NASA discipline program offices, the Principal Investigators, and appropriate engineering groups to assure that the scientific objectives of the missions are achieved.

Supporting Research and Technology

The supporting research and technology activities at MSFC are oriented to develop new technologies required for future science missions. The principal science areas are Astrophysics and Solar Physics. In 1980 definition study efforts for specific systems of an Advanced X-Ray Astrophysics Facility will be initiated as well as definition studies of the Gravity Probe-B (GP-B) and Space Science Platform.

SPACE APPLICATIONS — 390 Permanent Positions (Civil Service)

The civil service complement requested for this line item will be involved in four major space applications assignments: (1) Spacelab Mission 3, (2) Atmospheric Cloud Physics Laboratory, (3) Materials Processing in Space, and (4) Future Space Transportation System (STS) Payload Definition.

Spacelab Mission 3

Spacelab Mission 3, with a planned launch in mid-1982, will be the first use of a facility in space dedicated to the user community. Significant events that will occur in 1980 include initial design evaluation and final design and operations review of the integrated payload, selection and initiation of training for the payload specialist candidates and definition of initial requirements for support from the payload operations Control Center, Spacelab Data Processing Facility and STS Operations.

Atmospheric Cloud Physics Laboratory

Atmospheric Cloud Physics Laboratory (ACPL), under MSFC's management direction, will be flown in 1982 as a partial payload of Spacelab to provide the scientific community a unique multipurpose laboratory facility for conducting experimental atmospheric cloud physics research in a low-gravity environment. During 1980 the ACPL Critical Design Review will be completed and development testing of the engineering unit accomplished. Utilizing the engineering unit hardware, payload specialist training will be conducted and the first flight Principal Investigators (PI's) will conduct experiment testing to check out procedures, timelines and experiment-to-laboratory compatibility. Subsequently component acquisition and hardware update or refurbishment will be conducted. Flight 2 and 3 PI's will continue experiment development and the ACPL prime contract will be modified to initiate design and development of additional laboratory equipment to support advanced experiments. Systems engineering and integration will enter a critical phase to assure proper design, engineering, and scientific relationships among the areas of Spacelab-to-ACPL, man-machine constraints, and overall performance capability.

Materials Processing in Space

The Materials Processing in Space program emphasizes the fundamental science and technology of processing materials under conditions that allow detailed examination of the constraints imposed by gravitational forces. These studies are directed towards selected materials and processes which will best identify the limitations due to gravity as well as demonstrate the enhanced control that may be possible by the weightless environment of space. In 1980, the Materials Processing in Space program at Marshall Space Flight Center will include five major elements: (1) crystal growth and solidification, (2) containerless processing, (3) fluid and chemical processing, (4) vacuum research, and (5) commercialization studies. Expansion of the program to include a wider base of investigations using existing hardware is being planned. The activities include ground-based research, engineering and scientific analyses, advanced studies, and technical management of definition, design, development, and operation of material processing experiments, apparatus, and payloads.

Future Payload Definition and Supporting Research and Technology

Activities in this area include identifying and defining payloads which can fully capitalize on the new and unique capabilities of the STS and conducting related supporting research and technology necessary to pave the way for these missions and payloads. The 1980 milestones include the detailed investigation of user requirements for missions in the 1982 time frame and beyond. These user requirements will be used to develop conceptual definitions of candidate projects and missions. Efforts will be concentrated on the analysis of applications programs including weather and climate, communications, and geodynamics.

TECHNOLOGY UTILIZATION — 11 Permanent Positions (Civil Service)

The Technology Utilization program transfers new knowledge and innovative technology resulting from NASA's Research and Development programs for application in areas of the public sector, industry and medicine. MSFC civil service engineering and science personnel provide the primary source of technical skills necessary to accomplish the technology transfer to the public sector.

AERONAUTICAL RESEARCH AND TECHNOLOGY — 9 Permanent Positions (Civil Service)

The Aeronautics Research and Technology effort is concerned with aircraft operations and safety. The major activities in 1980 will be to continue studies of turbulence over the space of an aircraft wing, to perform gust correlations, to investigate the dissipation of fog, and to continue development of a Clear Air Turbulence (CAT) detection system. Field tests of the CAT detection system will be performed to provide verification data.

SPACE RESEARCH AND TECHNOLOGY — 94 Permanent Positions (Civil Service)

The major Space Technology discipline efforts at Marshall are in materials, structures, dynamics, high density circuit technology, guidance and control, large solar array technology, fluid chemistry, magnetics, electronic systems technology, and cryophysics and propulsion. In 1980, these efforts will focus on developing technology for high performance propulsion power systems and large space systems for the future.

Also in this area is the Standards and Practices program which provides for development of equipment for multimission applications and business practices to effect cost savings and for improvements in current and future space programs. In 1980, Civil Service personnel will continue to manage the development of those projects selected by the Standard Equipment Review Panels.

Also included in this area is the Shuttle/Spacelab Payloads effort concerned primarily with the Induced Environmental Contamination Monitor (IECM), the Solar Electric Propulsion (SEP) Solar Array, Geophysical Fluid Flow and Tribological Experiments. All of these areas will have continuing emphasis throughout 1980.

ENERGY TECHNOLOGY — 111 Permanent Positions (Civil Service)

MSFC activities include energy studies, development of a guidance and control system for coal extraction, and selected tasks for development in support of the National program for Solar Heating and Cooling.

Energy Studies

Energy from space encompasses definition studies in two areas: satellite power systems and nuclear waste management. Activities in 1980 will include the identification of system/subsystem requirements, development of conceptual designs and operational scenarios, development and impact of technology requirements, concept evaluations and selections and economic cost model development.

Automated Coal Extraction

The Department of Energy has overall responsibility for developing an automated longwall shearer mining system which will improve productivity and enhance health and safety of the miners. MSFC is working with the Department of Energy to define a prototype automated Longwall Guidance and Control System. Activities will include program and contract management, design, fabrication, test of experimental sensors and controls, data evaluation, and systems analysis.

Solar Heating and Cooling

MSFC is responsible for supporting two major programs of the overall National program for Solar Heating and Cooling: (1) the "Development in Support of Demonstration Program" and (2) the "Commercial Demonstration Program." The purpose of the Development in Support of Demonstration Program is to use present technology and technology emerging from the national research and technology program to bring solar heating and cooling systems and subsystems to the point where they will be tested and ready for use in residential and commercial applications. The Commercial Demonstration Program is organized to encourage the use of solar energy in commercial applications and to recommend and develop new ways to eliminate constraints against wide spread acceptance.

CENTER MANAGEMENT AND OPERATIONS SUPPORT — 611 Permanent Positions (Civil Service)

Center Management and Operations Support is defined as that support or services being provided to all Marshall Space Flight Center organizations which cannot be directly identified to a benefitting program or project. The civil service personnel involved are:

Director and Staff - The Center Director, Deputy Director, and immediate staff, e.g., Comptroller, Legal Patent Counsel, Equal Opportunity, Public Affairs, and Safety.

Management Support - Includes a wide range of activity categorized as management support for programs and functional organizations for the entire Center. Specific functions include resource and budget analysis, program control, contracting and procurement, personnel management, property management, resource control and management information systems and analysis.

Operations Support - This is a broad spectrum of activity that is required to maintain and operate facilities, buildings, and equipment; and to provide the normal housekeeping services and logistics support for the personnel who manage and conduct the affairs of the Center. Specific activities are:

Maintenance and operation of all buildings and facilities
Date processing and computer support
Reliability and quality assurance
Center-wide security and protection
Fire protection
Custodial services
Logistics support including transportation, supplies
Medical care of employees
Photographic and graphic support
Energy management

PERSONNEL AND RELATED COSTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
I. PERSONNEL AND RELATED COSTS	115,638	114,413	120,323	119,961
Basis of Fund Requirements				
A. Compensation and Benefits				
1. Compensation				
a. Permanent positions	102,608	101,254	106,254	105,945
b. Nonpermanent	880	1,150	1,387	1,388
c. Reimbursable details	125	144	137	69
d. Overtime and other compensation	787	792	785	786
Subtotal, Compensation	104,400	103,340	108,563	108,188
2. Benefits	10,876	10,702	11,221	11,205
Subtotal, Compensation and Benefits	115,276	114,042	119,784	119,393
B. Supporting Costs				
1. Transfer of personnel	218	196	217	246
2. Personnel training	144	175	322	322
Subtotal, Supporting Costs	362	371	539	568
Total, Personnel and Related Costs	115,638	114,413	120,323	119,961

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
A. Compensation and Benefits	115,276	114,042	119,784	119,393
1. Compensation	104,400	103,340	108,563	108,188
a. Permanent positions	102,608	101,254	106,254	105,945

The funds shown above will support 3,561 permanent positions in 1980. The increase from the 1979 budget estimate to the 1979 current estimate is due to the October 1978 pay raise partially offset by lower manpower levels. The decrease in 1980 from 1979 is due to a reduction of positions in 1980 partially offset by two extra work days and a decrease in reimbursable activity.

Basis of Cost for Permanent Positions

In 1980 the cost of permanent positions will be $105,945,000, a decrease of $309,000 under 1979. This decrease is calculated as follows:

Cost of permanent positions in 1979		106,254
Cost Increase in 1980		+3,150
Within grade advances and career development:		
Full year effect of 1979 actions	+718	
Partial year effect of 1980 actions	+695	
Full year effect of 1978 pay increases	+156	
Decrease in reimbursable activity	+751	
Two extra days	+830	
Cost Decrease in 1980		-3,459
Turnover savings and abolished positions:		
Full year effect of 1979 actions	-1,873	
Partial year effect of 1980 actions	-1,586	
Cost of permanent positions in 1980		105,945

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
b. Nonpermanent positions				
1. Cost	880	1,150	1,387	1,388
2. Workyears	108	151	155	150

The 1979 current estimate increases from the 1979 budget estimate are due to the addition of an experimental part-time program to encourage use of part-time employees where feasible. The 1980 estimate reflects a slight decrease in workyears as a result of the absorption of the part-time program into the permanent position ceiling. The 1980 plan includes 150 workyears which will be used to support the following programs at the approximate levels shown below:

Distribution of Nonpermanent Workyears by Program

Program	Workyears
College cooperative training	54
Summer employment	27
Youth opportunity	48
Other temporary employment	21
Total	150

c. Reimbursable detailees	125	144	137	69

Reimbursable detailees are assigned to NASA from DOD to support the Center in the field of solid rocket motors and in the use of the Neutral Buoyancy Simulator. The simulator is used in the development of operational procedures and the evaluation of design concepts to assure flight hardware will function in space (effort supports development, design, instrumentation, and engineering techniques for Spacelab Transfer Tunnel, STS Power Module, Shuttle Payload Bay and Solar Array Systems). This effort provides mutual benefits to NASA and DOD by providing NASA with special talents and by keeping DOD personnel current on manned space flight technology. The decreased cost in 1979 from the budget estimate to the current estimate is due to the release of one Navy diver supporting the Neutral Buoyancy Simulator activity. In 1980 two Air Force detailees will be released which results in the lower funding requirement.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
d. Overtime and other compensation	787	792	785	786

The decrease from the 1979 budget estimate to the 1979 current estimate reflects the use of Government housing for the Spacelab resident office personnel in support of the European Space Agency, offset by increased overtime activity in the Shuttle testing programs and the effect of the October 1978 pay raise. The 1980 costs are essentially the same as 1979.

2. Benefits	10,876	10,702	11,221	11,205

The distribution of these costs by major categories is as follows:

Category of Cost				
Civil Servire Retirement Fund	7,211	7,076	7,418	7,361
Employee life insurance	450	445	476	476
Employee health insurance	2,066	1,901	2,133	2,158
Workmen's compensation	1,040	1,113	1,059	1,075
FICA	18	39	51	51
Incentive awards	81	84	84	84
Severance pay	10	44	---	---
Total	10,876	10,702	11,221	11,205

The increases in 1979 are primarily due to the October 1978 pay raise partially offset by manpower reductions in 1979. The 1980 decreases are due to continuing manpower reductions offset by the two extra days and the reduced reimbursable activity.

B. Supporting Costs	362	371	539	568
1. Transfer of personnel	218	196	217	246

The estimated costs provide for certain relocation costs, such as the expenses of selling and buying a home and the movement of household goods. The increase shown from 1979 budget to the 1979 current estimate is due to increased temporary living expenses and real estate transaction costs. The 1980 increase reflects the return of the Spacelab personnel supporting the European Space Agency.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
2. Personnel training	144	175	322	322

The purpose of the MSFC training program is to continue the development of skills and knowledge of civil service employees in order to more efficiently support MSFC's roles and missions. The benefits to be derived by NASA from the training and educational programs conducted at MSFC, include: enhancement of scientific and engineering leadership in the scientific community; maintenance of a high degree of professional competency within the administrative and clerical work force; development of needed skills and knowledge required in MSFC mission activities; and extending MSFC work force capability and increasing productivity. The increase in 1979 reflects the return to the 1977 operating level which is necessary to support on-going programs and new directions for the MSFC work force. The training program for 1980 is planned at the same level of effort as 1979.

TRAVEL

II. TRAVEL	2,326	2,382	2,492	2,684
Basis of Fund Requirements				
A. Program Travel	2,172	2,157	2,288	2,463
B. Scientific and Technical Meeting Travel	24	30	26	28
C. Management and Operations Travel	130	195	178	193
Total, Travel	2,326	2,382	2,492	2,684

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
A. Program Travel	2,172	2,157	2,288	2,463

Program travel is directly related to the accomplishment of the Center's mission and is approximately 92 percent of the total MSFC travel. Travel requirements include those for on-going programs such as the Space Shuttle Main Engine, External Tank and Solid Rocket Booster, STS Operations, Spacelab, Inertial Upper Stage, Space Telescope, High Energy Astronomy Observatory, Teleoperator Retrieval Systems, space science and applications payloads and basic and supporting research and technology. Travel for Spacelab, Spacelab Payloads and Space Telescope will require both domestic and European travel. The increased level in the 1979 current estimate and the 1980 estimate reflects a higher level of program activity than previously planned. The increase in the 1980 level over the 1979 level is also effected by the return of employees assigned to the European resident offices.

B. Scientific and Technical Meeting Travel	24	30	26	28

Scientific and Technical Meeting travel permits employees to participate in meetings and technical seminars with representatives of the aerospace community. This participation allows them to benefit from exposure to technological advances outside MSFC, as well as to present both accomplishments and problems to their associates. Many of the meetings are working panels convened to solve problems for the benefit of NASA.

C. Management and Operations Travel	130	195	178	193

Management and Operations travel is required for the direction and coordination of general management matters. It includes travel by managers in such areas as personnel, financial management, and procurement activities and travel of the Center's top management to NASA Headquarters, other NASA Centers, and local transportation.

FACILITIES SERVICES

The Marshall Space Flight Center (MSFC) occupies over 1,841 acres under Department of the Army permit in a complex of science and engineering laboratories, special development and test facilities.

This complex encompasses 3,683,985 gross square feet of building space including 18 major buildings. Also included are 17 major technical facilities. This physical plant houses an average daily on-Center population of 5,000 to 5,500 personnel. Many of the test facilities are utilized on more than one shift or during off-peak hours.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
III. FACILITIES SERVICES	11,775	10,598	11,849	12,395
Basis of Fund Requirements				
A. Maintenance and Related Services				
1. Facilities	2,465	1,290	1,984	2,190
2. Equipment	210	94	172	182
Subtotal	2,675	1,384	2,156	2,372
B. Custodial Services	3,155	2,682	2,899	3,077
C. Utilities Services	5,945	6,532	6,794	6,946
Total, Facilities Services	11,775	10,598	11,849	12,395
A. Maintenance and Related Services	2,675	1,384	2,156	2,372
1. Facilities	2,465	1,290	1,984	2,190

This activity involves a total of 235 facilities (buildings, structures, and trailers) with 3.7 million square feet of floor area. Also involved are 1,841 acres of land area, 1 million square yards of surfaced area, and several special structures and systems.

The increase from the 1979 budget estimate is due to 1978 experience. The funding for 1980 reflects approximately the same level of services as in 1979.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
a. Maintenance of buildings and grounds				1,579

The estimate includes 32 workyears of support contractor effort and reimbursements to the Army (Redstone Arsenal) for facility maintenance and related services for such items as electrical distribution lines and paved surfaces.

b. Supplies and Materials				611

This estimate provides for the acquisition of building materials, electrical materials, electronic materials, general maintenance materials, general operating materials, general service materials, metals, gauges, pipes, valves, and fittings.

2. Equipment	210	94	172	182

This activity includes six workyears of support contractor effort and involves maintenance and repair of over 3,675 items of building equipment at MSFC. The 1979 current estimate reflects 1978 experience. The 1980 level remains approximately the same as in 1979.

B. Custodial Services	3,155	2,682	2,899	3,077

Custodial Services includes janitorial services, security services, fire protection, trash removal, sanitary landfill operations, pest control activities, and related supplies and materials. The increase in 1980 provides for negotiated support contractor wage increases.

1. Janitorial Services				1,606

This activity provides service to about three million square feet of facility space and trash removal from approximately 125 separate locations. Work is performed through a support contractor with a level of effort of 110 workyears.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
2. Security and Fire Protection				1,449

Services are provided by a support contractor with a level of effort of 39 workyears and through the Army (Redstone Arsenal). Included are 24-hour security coverage of MSFC property, law enforcement, motor vehicle control and registration, as well as fire protection.

3. Minor Requirements				22

Services are related to landfill operations and "as needed" pest control.

C. Utilities Services	5,945	6,532	6,794	6,946

The Army (Redstone Arsenal) provides electricity, steam, water, and sewage disposal services to MSFC on a reimbursable basis, and the estimates, therefore, are included in this activity. Also included are four workyears of effort to operate and maintain 12 separate steamboilers for facilities not on the central system, the environmental control systems, and to provide a nonduty hour focal point for emergencies. The increase in 1980 provides for increased utility rates partially offset by reduced consumption. The cost of purchased commodities is shown in the following table:

1. Electricity (100,000 mW/Hrs.)	3,500
2. Propane (48,000 gals.)	21
3. Fuel oil (657,000 gals.)	284
4. Steam (383,000 K/lbs.)	2,394
5. Water and sewage	572

TECHNICAL SERVICES

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
IV. TECHNICAL SERVICES	5,636	6,418	5,728	5,588
Basis of Fund Requirements				
A. Automatic Data Processing				
1. Equipment	823	803	800	812
2. Operations	2,509	3,521	2,810	2,706
Subtotal	3,332	4,324	3,610	3,518
B. Scientific and Technical Information				
1. Library	807	761	715	720
2. Education and information	144	126	134	142
Subtotal	951	887	849	862
C. Shop Support and Services	1,353	1,207	1,269	1,208
Total, Technical Services	5,636	6,418	5,728	5,588
A. Automatic Data Processing	3,332	4,324	3,610	3,518

Provides centralized systems analysis, programming, operations, and related computational services to meet the management and administrative computing requirements. Also includes maintenance of ADP equipment and related supplies and materials. Included are 129 workyears of support contract effort.

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	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
1. Equipment	823	803	800	812

Maintenance is provided under separate contracts for central site computers and associated equipment. Equipment maintained includes two large Univac 1108 systems, CalComp Disc secondary storage system for the Univac 1108 system, and a key-to-disc which collects, controls, organizes, and edits raw data for input into the Univac 1108 system. This effort is being maintained at approximately the current level of funding.

2. Operations	2,509	3,521	2,810	2,706

This function provides for the development and utilization of computer techniques and systems programming of all digital computers and associated equipment at MSFC. The computer systems include the two large Univac 1108 systems, seven Univac 9300 Remote Job Entry terminals, one IBM 1401, and two FR-80 Electronic plotters. Also included is associated auxiliary support equipment such as film processors, Xerox microfiche printers, Xerox forms copiers, and punch card accounting machines (PCAM). Also included are the operation of two large magnetic tape libraries containing a combined total of 60,000 reels; receipt, control, and distribution of program and data processing products ; and testing and cleaning of magnetic tapes.

Also included in the operation costs are program design and development, and development of data base management, configuration management, and accounting software systems. Support is also provided for developing engineering drawings and parts management systems. Costs remain essentially level from year-to-year, however, the amount is substantially less than the 1979 budget level due to the programmatic operations taking over approximately 44 workyears of effort.

B. Scientific and Technical Information	951	887	849	862

This activity provides for the operation of the Redstone Scientific Information Center library at MSFC and support to the Center in various scientific and technical information services.

1. Library	807	761	715	720

Scientific information and library services are provided to MSFC employees and associated contractor personnel through the Redstone Scientific Information Center (RSIC) operations. The RSIC contains a central

collection of 234,000 books and journals, 3,000 periodicals, 1,000,000 documents on microfilm and 400,000 technical papers. Operation of the RSIC by the Army is under direction of a joint MSFC/Army Redstone Scientific Information Board with costs shared. The 1980 estimate provides for the same level of service as in 1979.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
2. Education and information.....	144	126	134	142

The funds provide for the preparation of reproducible pages for publication of technical manuscripts and related documents. The annual volume of work under this contract is an estimated 12 thousand manuscript pages. Also included is MSFC's share of the operation of the MSFC Visitor Information Center located at the Alabama Space and Rocket Center. This effort is being maintained at approximately the current level of funding.

C. Shop Support and Service.....	1,353	1,207	1,269	1,208

Twenty-seven workyears of support contractor effort provide the Center with support in the areas of graphics, models and design, construction, and management of exhibits. Related supplies, materials and equipment are also included in this activity. Graphic materials are prepared for use in such presentations as senior management meetings. The decrease from 1979 reflects the reduction of eight workyears of support contractor effort.

1. Instrumentation support..... 26

This category provides funds for guage calibration services work procured from the Army (Redstone Arsenal). Included are microwave, radio frequency, and optical and acoustic instrumentation calibration.

2. Photographic services..... 446

Consists of procurement of off-site commercial still photographic and motion picture production services. Still photographic services include printing and processing of color and black and white prints, slides, vugraphs, and copy camera photography. Motion picture production services include script writing; film editing; sound recording; and printing and processing of sound motion pictures. Approximately 138,000 still photo units and 240,000 feet of motion picture service are needed annually.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
3. Graphics				736

Twenty-seven workyears of support contractor effort required for the preparation of charts, graphs, vugraphs and similar visuals for administrative and operational requirements are included in this activity. Approximately 35,000 work units are completed annually. Also includes the design, construction, and management of exhibits in connection with MSFC's Public Affairs activity.

MANAGEMENT AND OPERATIONS

V. MANAGEMENT AND OPERATIONS	8,070	7,046	7,884	8,256
Basis of Fund Requirements				
A. Administrative Communications	2,380	2,044	2,529	2,603
B. Printing and Reproduction	451	380	475	487
C. Transportation	2,016	1,777	2,196	2,325
D. Installation Common Services	3,223	2,845	2,684	2,841
Total, Management and Operations	8,070	7,046	7,884	8,256
A. Administrative Communications	2,380	2,044	2,529	2,603

Communications support for MSFC, which includes 25 workyears of support contractor effort, consists of local telephone service, long distance telephone service, and various kinds of other nontelephone communications.

1. Local telephone service	802

The MSFC Central Exchange provides instruments and lines at the Center for local telephone service. This effort is being maintained at the current level of funding.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
2. Long distance telephone service				998

Provides for MSFC use of the GSA operated long distance Federal Telecommunications System telephone network. Costs result from a formula which is based primarily on the number of calls made two years in the past and the number of circuits used by the Center. Also included are such items as long distance commercial tolls, Western Union leased equipment for transmitting and receiving telegraphic messages and the Autodin network for ordering supplies and materials and sending and receiving classified information.

3. Nontelephone communications				803

These funds provide for use of Weeden Mountain radio transmission facilities, support of the Emergency Warning System, and operation of MSFC's Fire Surveillance System. Also provided are payments for entry into the GSA teletype system for Government subscribers, entry into the Western Union teletype system for commercial subscribers, overseas telegrams and cable system upkeep and equipment storage by the Army. Twenty-five workyears of support contractor effort is required to provide around-the-clock institutional communications capability, including installation, operation, maintenance and repair of 2,200 capital equipment items; 797,280 operating feet of cable; handling 90,000 telephone calls by operators on three switchboards; receiving/transmitting teletype messages; making 6,000 telephone directory changes; processing 3,000 video tapes and 875 engineering drawings. The decrease from 1979 to 1980 is due primarily to the reclassification of postage costs to Installation Common Services which is offset somewhat by negotiated support contractor wage rate increases.

B. Printing and Reproduction	451	380	475	487

A portion of MSFC's printing/reproduction requirements are met by an on-site reproduction plant operated by MSFC personnel. This reproduction plant produces approximately 18,000,000 units of reproduction work each year. In addition to the on-site reproduction plant, MSFC must also purchase from the Government Printing Office, Army and private firms about 24,000,000 units of printing each year. This purchased printing is either an overflow requirement that cannot be handled within the on-site workload, or is such a type that cannot be handled with the limited capability of the on-site equipment. Included in the cost of printing and reproduction are four support contractor workyears of effort. The increase from 1979 to 1980 reflects negotiated support contractor wage increases and the full year effect of increased costs for procured printing services.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
C. Transportation	2,016	1,777	2,196	2,325

Transportation functions at MSFC include 56 workyears of support contractor effort for operation and maintenance of vehicles and aircraft, and transportation of things. Included in this category is the maintenance of 418 general purpose vehicles, 108 general and special purpose trailers and vehicles, 290 pieces of equipment such as "A" frame cranes, "H" frame cranes, cranes, tractors, generators, and welders; intermediate inspections at 6,000 miles or six months; and major inspections at 12,000 miles or twelve months. Freight charges for shipment by both surface and air transportation of materials and equipment are also included. The increase from the 1979 budget estimate to the current estimate reflects 1978 experience and current price levels.

The increase in funds from 1979 to 1980 is due mainly to increased costs of support contracts.

D. Installation Common Services	3,223	2,845	2,684	2,841

This category includes 38 workyears of support contractor effort and provides support to Center Management and staff activities, medical services, and various other installation support services. The decline in the funding level from 1978 to 1979 is due primarily to the one-time procurement in 1978, of some mechanical, electrical, and office equipment.

The increase in 1980 is due to increased wage rates in the medical contract, increased cost of maintenance and repair of equipment, and increased postage costs.

1. Center management and staff functions..... 46

   Includes Patent Counsel Services, Tort Claims and Equal Opportunity activities.

2. Medical services..... 728

   Provides occupational medicine and environmental health services totaling 18 workyears of support contract effort for the maintenance and improvement of employee health at MSFC, with emphasis on prevention, diagnosis, treatment and care of illnesses and injuries caused or aggravated by the work environment.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		

3. Installation support services..... 2,067

Maintenance and repair of office equipment, equipment rental, acquisition of supplies and materials and miscellaneous services are included in this activity.

a. Maintenance and repair of equipment..... 481

Maintenance and repair of office equipment includes the maintenance and repair services for office machines and equipment (i.e., typewriters, calculators, time stamp equipment, etc.); maintenance and repair services for photographic and reproduction equipment (i.e., enlargers, cameras, exposure controls, print copiers, projectors, power supplies, tape recorders, stroboflash, film viewer, motion analyzer, copiers, copy camera, processor camera, super diazo, etc.).

b. Rental of equipment..... 185

Rental of equipment such as Xerox machines at the resident office at Canoga Park, California and Visual Search Microfilm Files located at MSFC, and other reproduction equipment are included in this category.

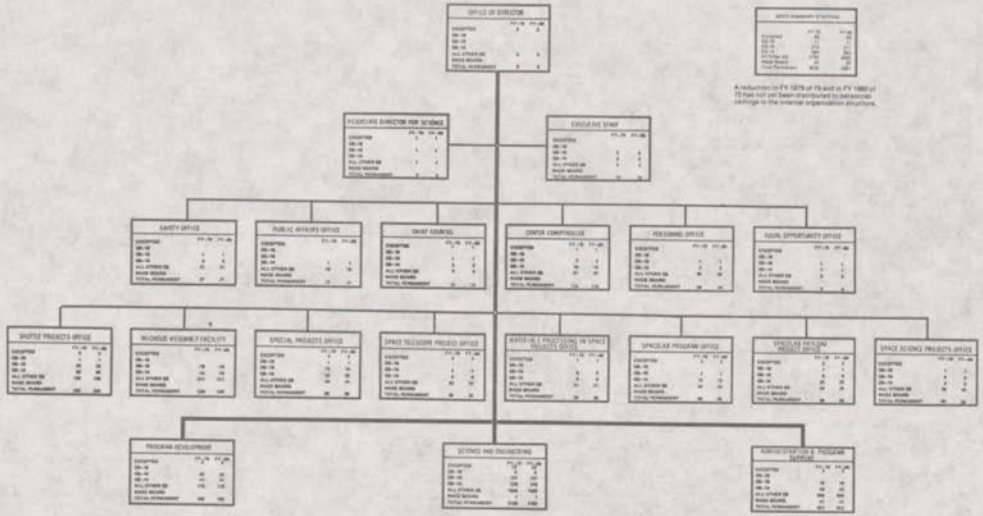
c. Supplies, materials, and equipment..... 447

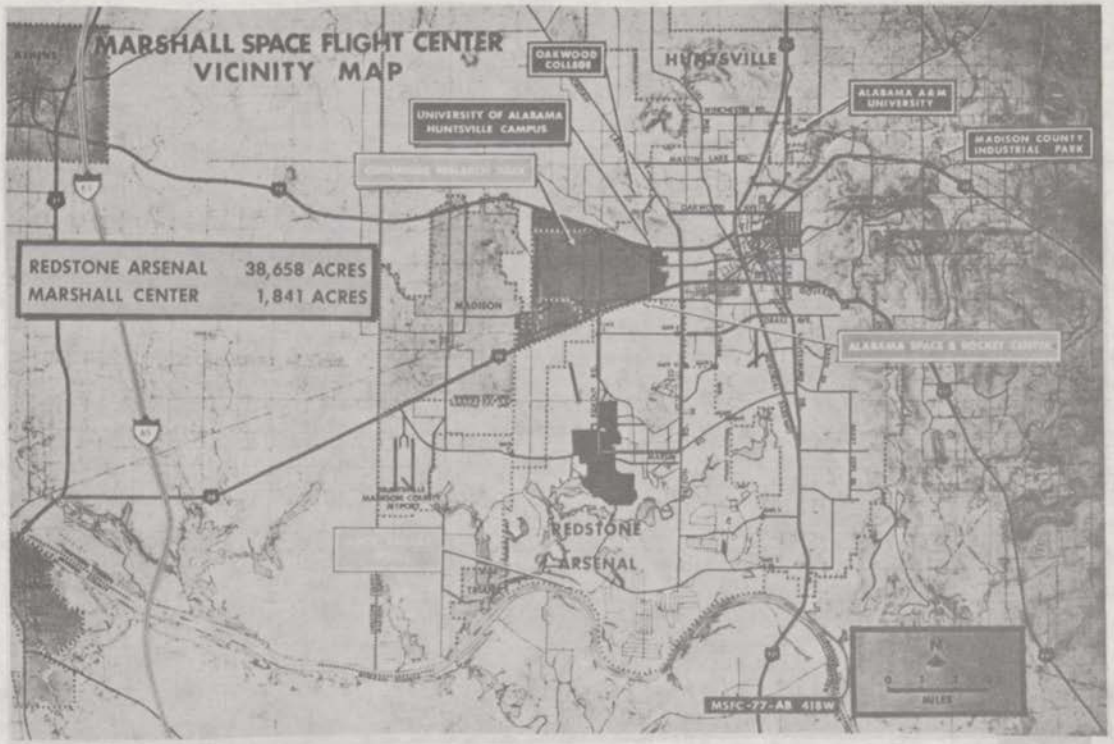
Acquisition of primarily office type supplies and equipment.

d. Miscellaneous services..... 954

This estimate includes services such as miscellaneous troop service charges for military detailees assigned to MSFC; disposal of toxic wastes; inspection of hazardous cargo prior to entry to Redstone Arsenal; receipt, storage, and issue services for hazardous materials such as explosives, pyrotechnics and solid rocket motors. Minor contracts include laundry service, furniture repair, potassium cyanide disposal and logistics support which include 20 workyears of support contract effort. Postage costs are also included.

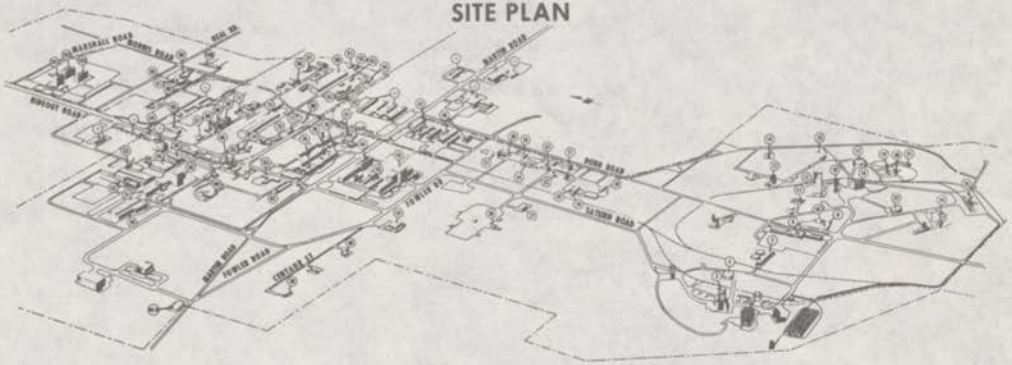
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER




MARSHALL SPACE FLIGHT CENTER
VICINITY MAP
OAKWOOD COLLEGE
HUNTSVILLE
UNIVERSITY OF ALABAMA HUNTSVILLE CAMPUS
ALABAMA A&M UNIVERSITY
MADISON COUNTY INDUSTRIAL PARK
REDSTONE ARSENAL 38,658 ACRES
MARSHALL CENTER 1,841 ACRES
MADISON
ALABAMA SPACE & ROCKET CENTER
REDSTONE ARSENAL
MSFC-77-AB 418W
MILES

RPM 3-30

MARSHALL SPACE FLIGHT CENTER
SITE PLAN



HEADQUARTERS AREA

95	4019	COMMUNICATIONS FACILITY
96	4061	SHOP AND STORAGE BUILDING
97	S-4068	STORAGE BUILDING
98	S-4051	EQUIPMENT SHED
99	4050	OFFICE AND SHOP BUILDING
100	4049	OFFICE BUILDING
101	4090	OFFICE BUILDING
102	4092	OFFICE BUILDING
103	4055	OFFICE BUILDING

LAB AND SUPPORT AREA

38	4628	CRYOGENIC TESTING FACILITY
40	4623	LABORATORY BUILDING
42	4635	NON-DESTRUCTIVE EVALUATION LABORATORY
43	4612	MATERIALS LABORATORY
44	4610	OFFICE AND ENGINEERING BUILDING
45	4619	STRUCTURES AND MECHANICS LABORATORY
46	4650	SHOP AND CALIBRATION LABORATORY
47	4663	COMPUTER FACILITY
49A	4740	WATER POLLUTION CONTROL FACILITY
50	4708	ENGINEERING AND DEVELOPMENT LABORATORY
51	4760	SURFACE TREATMENT FACILITY
52	S-4726	NEUTRAL BUOYANCY FACILITY
53	4708	FABRICATION AND MACHINE SHOP
53A	4775	HIGH REYNOLDS FACILITY
53B	4467	CELESTIAL & OPTICAL SENSORS FACILITY
54	4723	TRAINING FACILITY
55	4711	DEVELOPMENTAL PROCESSES LABORATORY
56	4712	OFFICE BUILDING
59	4707	SHOP AND ASSEMBLY BUILDING
62	S-4740	AIR COMPRESSOR BUILDING
63	4746	CALIBRATION LABORATORY
65	4732	SUSONIC WIND TUNNEL FACILITY
66	4733	IMPULSE BASE FLOW FACILITY
67	4706	OFFICE BUILDING
68	4532	OFFICE BUILDING
69	4511	SHOCK TUNNEL FACILITY
70	4533	SHOP BUILDING
71	4532	ENVIRONMENTAL TEST LABORATORY
73	4471	STORAGE AND OFFICE BUILDING
74	4485	OFFICE BUILDING
75	4491	OFFICE AND LABORATORY BUILDING
76	4487	LABORATORY AND OFFICE BUILDING
77	S-4479	STORAGE SHED
78	4476	ENVIRONMENTAL TEST FACILITY
79	S-4436	AUTOMATION CHECKOUT BUILDING
80	4492	ELECTRICAL SYSTEMS LABORATORY BUILDING
81	4475	HAZARDOUS OPERATIONS LABORATORY
82	4493	SHOP AND STORAGE BUILDING
83	4483	VEHICLE MAINTENANCE SHOP
86	4553	PHOTO LAB
87	4572	MILLIMETER WAVELENGTH BUILDING
90	4481	SPACE SCIENCES LABORATORY
91	S-4498	STORAGE BUILDING
92	S-4499	STORAGE BUILDING
93	4482	TRANSPORTATION SUPPORT BUILDING
94	4494	CENTER ACTIVITIES BUILDING

TEST AREA

WEST AREA

2	4670	PROPULSION & STRUCTURAL TEST FACILITY
4	4674	BLOCKHOUSE
7	4667	PUMP HOUSE
8	4666	OFFICE BUILDING
8A	4699	STRUCTURAL TEST FACILITY

EAST AREA

9	4566	DOCUMENTATION REPOSITORY
10	4567	PUMP AND BOILER HOUSE
11	S-4549	DEIONIZED WATER PLANT
12	4550	STRUCTURAL TEST FACILITY
13	4522	PROPULSION SYSTEMS COMPONENT TEST STAND
14	4530	PROPULSION SYSTEMS COMPONENT TEST STAND
15	4561	SHOP AND LABORATORY BUILDING
16	4557	STRUCTURAL TEST FACILITY
17	4565	TEST AND DATA RECORDING FACILITY
18	4540	PROPULSION SYSTEMS COMPONENT TEST FACILITY
19	S-4539	TEST STAND SUPPORT BUILDING
20	4540	MODEL PROPULSION SYSTEMS TEST STAND (ACOUSTIC)
21	4541	TEST STAND CONTROL BUILDING
22	4570	BLOCKHOUSE AND CABLE TUNNELS
24	4534	PROPULSION SYSTEMS TEST STAND
25	4572	PROPULSION AND STRUCTURAL TEST FACILITY

TEST SUPPORT AREA

26	4646	OFFICE BUILDING
27	4648	HIGH PRESSURE TEST FACILITY
28	S-4659	HP GN2 FACILITY
29	S-4660	BOILER PLANT
30	S-4647	COMPRESSOR BUILDING
31	S-4655	MULTI-PURPOSE HIGH BAY FACILITY
32	S-4656	HYDRAULIC EQUIPMENT DEVELOPMENT FACILITY
33	S-4653	COMPONENTS SERVICE BUILDING
34	4673	OFFICE AND STORAGE BUILDING
35	S-4654	OFFICE BUILDING
36	S-4651	SHOP BUILDING
37	4649	MULTI-PURPOSE HIGH BAY FACILITY

MICHOUD ASSEMBLY FACILITY

SITE PLAN



MANUFACTURING AND ASSEMBLY

1	303	HANGAR
2	103	MANUFACTURING
3	111	LABORATORY
4	104	BATTERY CHARGING & STORAGE
5	207	BOILER HOUSE
6	202	COOLING TOWER
7	220	COMPONENT SUPPLY
8	203	MAINTENANCE SUPPLY
9	221	HAZARDOUS MATERIAL STORAGE

TEST FACILITIES

10	420	TEST & CHECKOUT FACILITY
11	404	HIGH PRESSURE TEST FACILITY
12	110	VERTICAL ASSEMBLY & HYDROSTATIC TEST
13	130	SYSTEMS ENGINEERING
14	451	PNEUMATIC TEST FACILITY

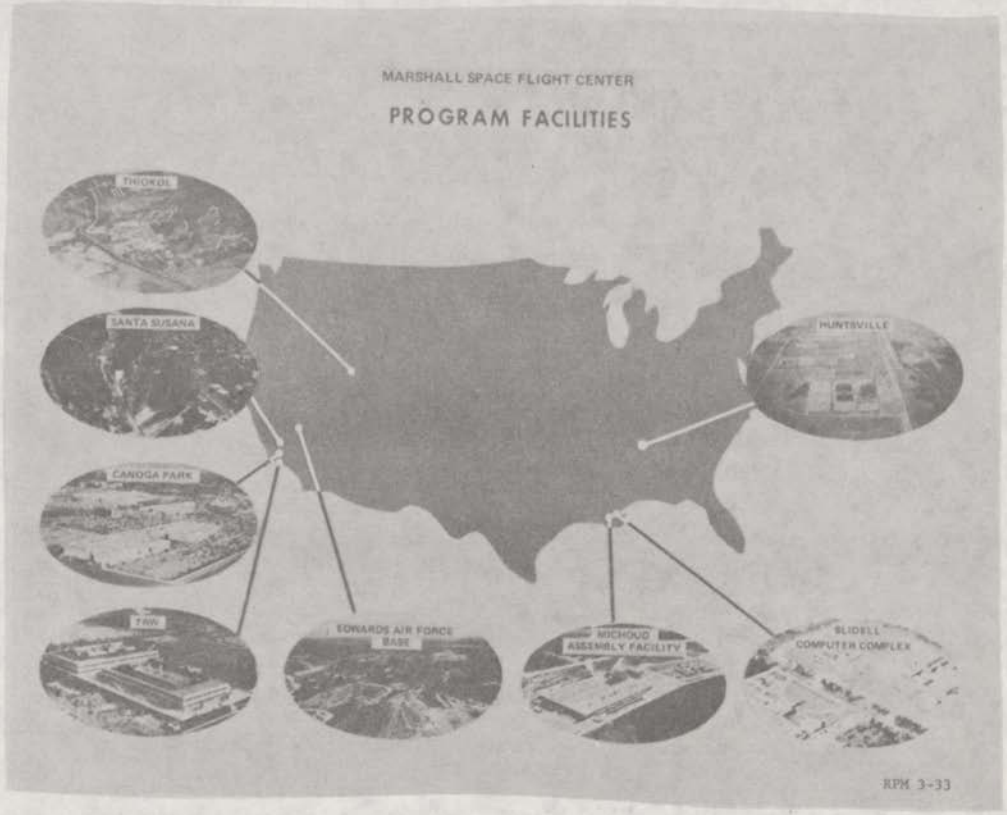
ENGINEERING & ADMINISTRATION

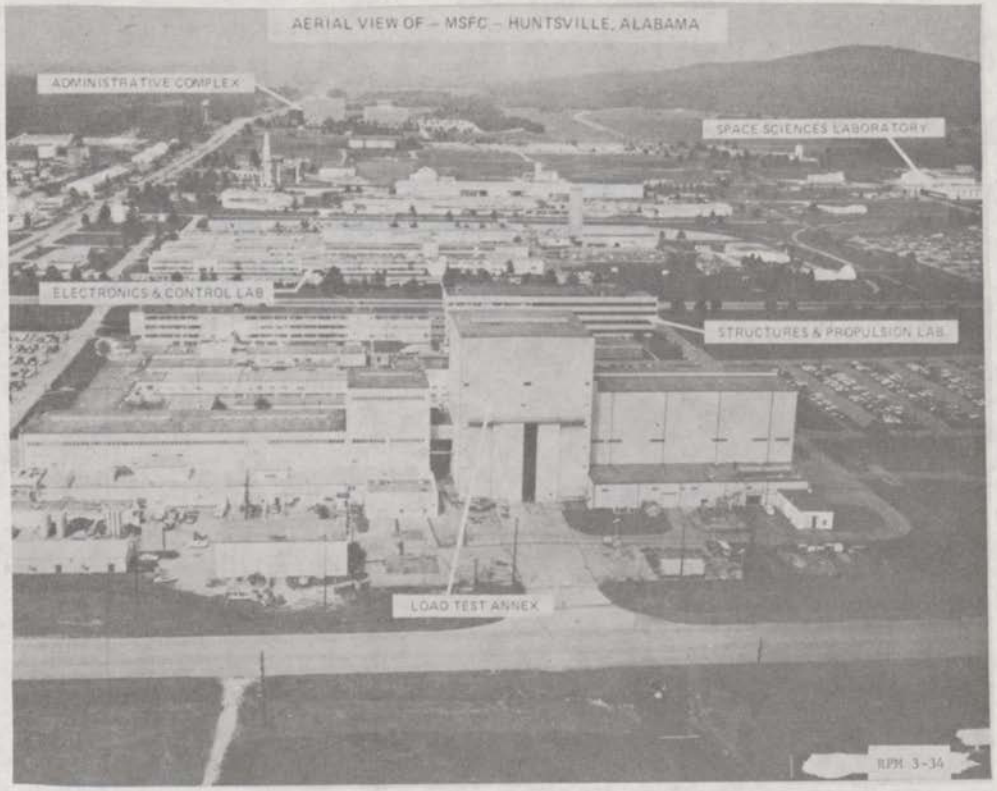
15	350	OFFICE AND ENGINEERING BUILDING
16	351	CAFETERIA
17	320	CONTRACTOR SERVICES BUILDING
18	101	ADMINISTRATION
19	102	ENGINEERING
20	301	MAINTENANCE SHOP

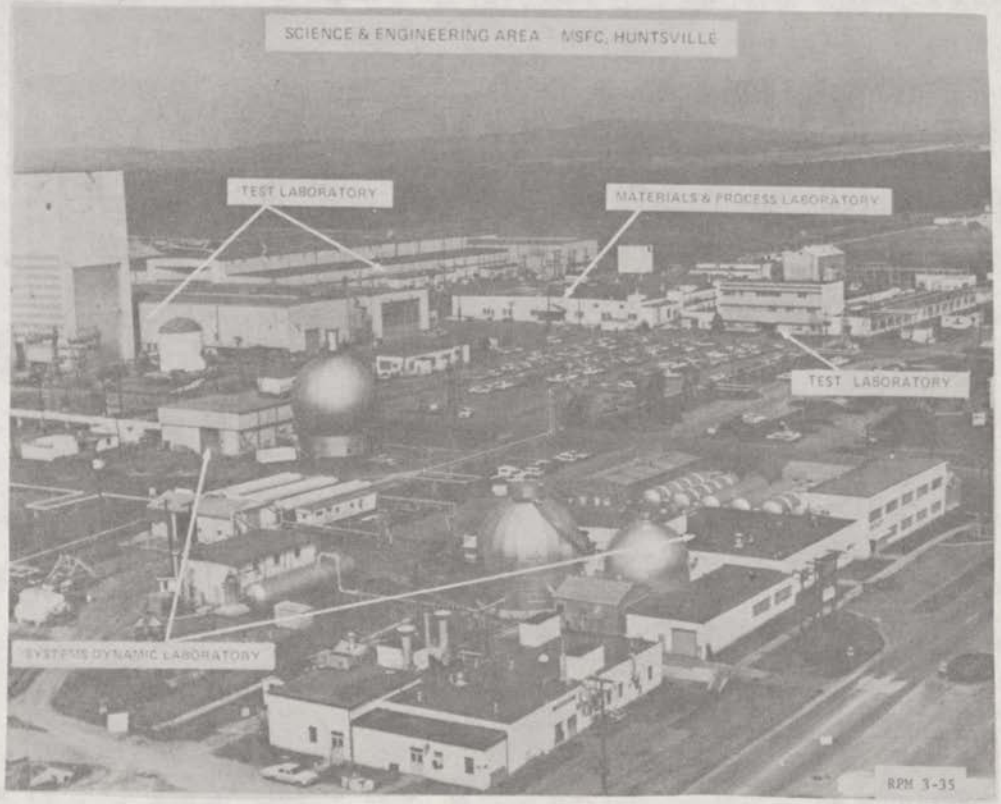
TRANSPORTATION, UTILITIES & MISC

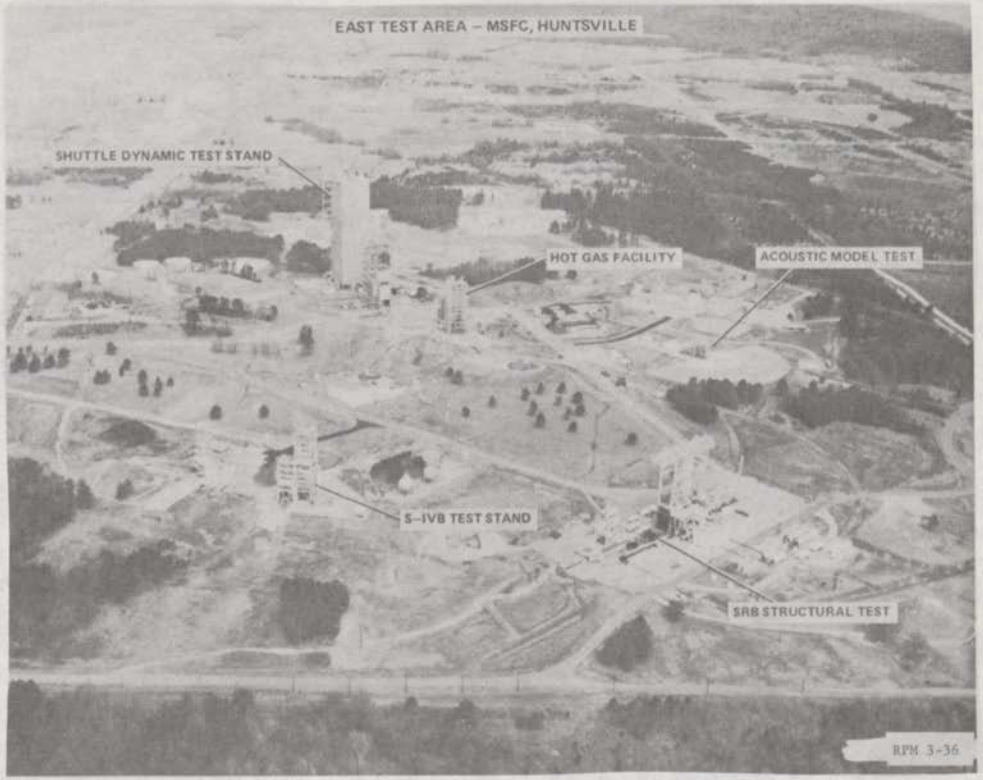
21	480	BARGE DOCK
22		GUARD HOUSE
23	450	MAIN PUMP STATION
24	201	PUMP STATION NO 1
25	304	PUMP STATION NO 3
26	143	PUMP STATION NO 4
27	308	WEST MASTER SUBSTATION
28	121	MAIN SUBSTATION
29	170	CHEMICAL WASTE LAGOON
30	119	PAINT SHOP
31	403	SALVAGE YARD
32	105	TRANSPORTATION
33	302	ELEVATED WATER TOWER

RPM 3-32

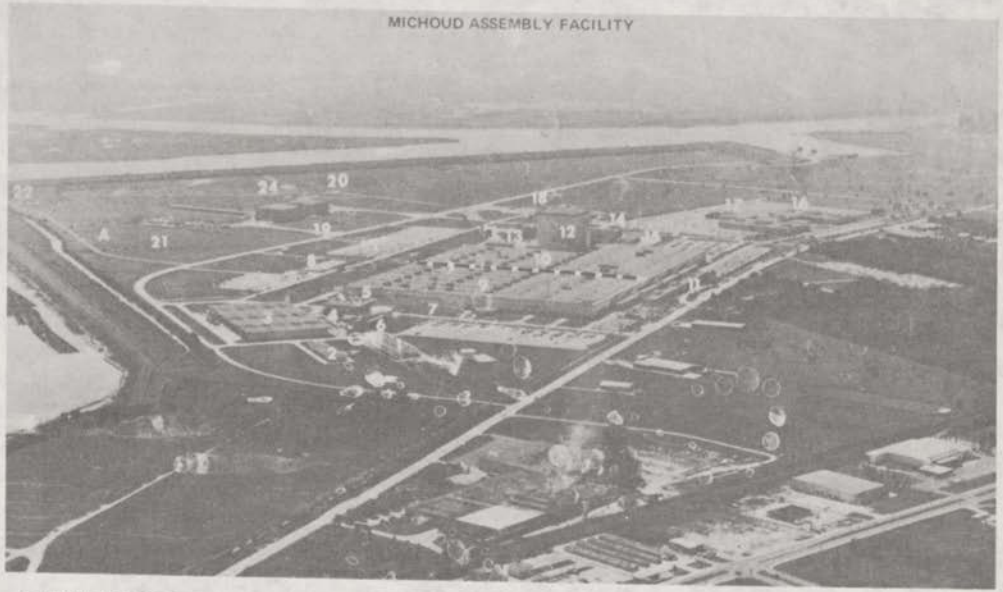

MARSHALL SPACE FLIGHT CENTER
PROGRAM FACILITIES
THIOKOL
SANTA SUSANA
CANOGA PARK
TWR
EDWARDS AIR FORCE BASE
MICHOUD ASSEMBLY FACILITY
SLIDELL COMPUTER COMPLEX
HUNTSVILLE
RPM 3-33


AERIAL VIEW OF – MSFC – HUNTSVILLE, ALABAMA
ADMINISTRATIVE COMPLEX
SPACE SCIENCES LABORATORY
ELECTRONICS & CONTROL LAB
STRUCTURES & PROPULSION LAB.
LOAD TEST ANNEX
RPM 3-34


SCIENCE & ENGINEERING AREA - MSFC, HUNTSVILLE
TEST LABORATORY
MATERIALS & PROCESS LABORATORY
TEST LABORATORY
SYSTEMS DYNAMIC LABORATORY
RPM 3-35


EAST TEST AREA – MSFC, HUNTSVILLE
SHUTTLE DYNAMIC TEST STAND
HOT GAS FACILITY
ACOUSTIC MODEL TEST
S–IVB TEST STAND
SRB STRUCTURAL TEST
RPM 3-36

MICHOUD ASSEMBLY FACILITY



1. MAINTENANCE SUPPLY
2. HAZARDOUS MATLS STORAGE
3. COMPONENT SUPPLY
4. BOILER PLANT & FUEL TANKS
5. BATTERY CHARGING
6. COOLING TOWER
7. LABORATORY
8. CHEMICAL WASTE RESERVOIR
9. FAB AREA
10. FAB AREA
11. ENGINEERING BUILDINGS
12. VERT ASSY & HYDROSTATIC TEST
13. SYSTEMS ENGINEERING BLDG.
14. HANGAR
15. MAINTENANCE
16. ENGINEERING & OFFICE BLDG.
17. CAFETERIA
18. CONTRACTOR SERVICES BLDG.
19. TEST & CHECK OUT
20. SALVAGE YARD
21. HIGH PRESSURE TEST FACILITY
22. MAIN PUMPING STATION
23. BARGE DOCK
24. PNEUMATIC TEST FACILITY

RPM 3-37

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1980 ESTIMATES

NATIONAL SPACE TECHNOLOGY LABORATORIES

DESCRIPTION

The National Space Technology Laboratories is located in southwest Mississippi, approximately 50 miles northeast of New Orleans, Louisiana. Total land area is 138,807 acres of which 13,480 acres make up the actual installation owned by NASA. The remaining 125,327 acres are held as a buffer zone. In the buffer zone, 7,162 acres are owned by NASA, and 118,165 acres are under restrictive easements. The installation has deep water access via the Pearl River and the Intracoastal Waterway. Capital investment for the National Space Technology Laboratories as of September 30, 1978, was $307,261,000.

CENTER ROLES AND MISSIONS

The National Space Technology Laboratories (NSTL), formerly the Mississippi Test Facility (MTF), was constructed and operated during the 1960's for acceptance testing of the booster stages of the Saturn V rocket system. NSTL is NASA's prime static test facility for large liquid propellant rocket engines and propulsion systems. The redesignation of this facility as NSTL in 1974 recognized the emerging role of the installation in space and environmental technology efforts.

NSTL is presently engaged in development and acceptance testing of the Space Shuttle Main Engines and development testing of the ground test version of the Shuttle Propulsion System, the Main Propulsion Test Article. NSTL conducts applied research, develops techniques, demonstrates and transfers to the user community applications of NASA-developed technology in the fields of remote sensing, satellite communication, environmental sciences, and other selected applications programs. NSTL manages the installation and, through interagency agreements, provides service support and full utilization of all facilities including collocated elements of other executive agencies engaged in compatible research, development, and operational activities. These include the Department of Interior, the Department of Commerce, the Environmental Protection Agency, the Department of Transportation, the Department of Defense, the State of Mississippi, and the State of Louisiana. The principal roles are:

Space Shuttle - NSTL provides, maintains and manages the facilities and the related capabilities required for the development and acceptance testing of the Space Shuttle Main Engines and the development testing of the Shuttle's main propulsion system.

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Space Applications - Conducts applied research, develops techniques, demonstrates and transfers to the user community applications of NASA-developed technology in the fields of remote sensing, satellite communication and environmental sciences.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
I. Personnel and Related Costs	2,648	2,823	3,083	3,151
II. Travel	84	65	92	99
III. Facilities Services	---	350	1,02[illegible]	1,173
IV. Technical Services	---	50	41	41
V. Management and Operations	---	200	217	225
Total, fund requirements	2,732	3,488	4,527	4,689

Distribution of Permanent Positions by Programs

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Direct Positions				
Space Transportation Systems	5	---	5	5
Space shuttle	5	---	5	5
Space and Terrestrial Applications	38	40	40	39
Space applications	38	40	40	39
Subtotal, direct positions	43	40	45	44

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Center Management and Operations Support Positions.....	59	64	59	59
Total, permanent positions.....	102	104	104	103

PROGRAM DESCRIPTION

SPACE TRANSPORTATION SYSTEMS — 5 Permanent Positions (Civil Service)

In 1980 the National Space Technology Laboratories will continue to provide, maintain, and manage the facilities and the related capabilities required for development and acceptance testing of the Space Shuttle Main Engines and the ground test version of the Shuttle propulsion system, the Main Propulsion Test Article.

SPACE AND TERRESTRIAL APPLICATIONS — 39 Permanent Positions (Civil Service)

In 1980 the National Space Technology Laboratories' Earth Resources Laboratory's program will continue:

a. To conduct research investigations in the application of remotely sensed data, stressing interests and needs of potential user agencies. This research activity uses existing aircraft and satellite programs as a basic source of remotely sensed data in conjunction with surface data to develop techniques and procedures for practical applications, and to devise cost-effective methods of transferring those techniques to the user agencies.

b. To conduct applications demonstration projects in cooperation with Federal, state, regional and local government agencies and private industry to promote the effective transfer of applications technology as well as to reduce systems costs, increase adaptation to the users systems, and improve compatibility with other information sources and products routinely used by the user organization.

c. To systematically transfer, primarily to state and local governments in the 17 state region in the midwest, south and southeast, the ability to effectively use Landsat data for their resource management and planning decisions through the Southern Regional Remote Sensing Applications Center.

d. To conduct research, develop applications and transfer technology to the user community in non-remote sensing applications primarily in such areas as data collection systems, environmental system development, and closed ecosystems development.

CENTER MANAGEMENT AND OPERATIONS SUPPORT — 59 Permanent Positions (Civil Service)

Center Management and Operations Support is defined as that support or services being provided to all National Space Technology Laboratories organizations which cannot be directly identified to a benefitting program or project. The civil service personnel involved are:

Director and Staff - The Center Manager, Deputy Director, and immediate staff, e.g. Legal, Patent Counsel, Equal Opportunity, and Public Affairs.

Management Support - Includes a wide range of activity categorized as management support for programs and functional organizations for the entire Center. Specific functions include resource and budget management, program control, contracting and procurement, personnel management, property management, financial management, resource control and management information systems and analysis.

Operations Support - This is a broad spectrum of activity that is required to maintain and operate facilities, buildings and equipment; and to provide the normal housekeeping services and logistics support for the personnel who manage and conduct the affairs of the Center. Specific activities are:

Maintenance and operation of all buildings and facilities
Data processing and computer support
Reliability and quality assurance
Centerwide security and protection
Fire protection
Custodial services
Logistics support including transportation, supplies, etc.
Medical care of employees
Photographic and graphic support
Safety

PERSONNEL AND RELATED COST

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
I. PERSONNEL AND RELATED COSTS	2,648	2,823	3,083	3,151

Basis of Fund Requirements

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
A. Compensation and Benefits				
1. Compensation				
a. Permanent Positions	2,327	2,484	2,680	2,768
b. Nonpermanent	49	62	101	79
c. Overtime and compensation	5	7	8	8
Subtotal, Compensation	2,381	2,553	2,789	2,855
2. Benefits	242	254	271	278
Subtotal, Compensation and Benefits	2,623	2,807	3,060	3,133
B. Supporting Costs				
1. Transfer of personnel	10	11	15	10
2. Personnel training	15	5	8	8
Subtotal, Supporting Costs	25	16	23	18
Total, Personnel and Related Costs	2,648	2,823	3,083	3,151
A. Compensation and Benefits	2,623	2,807	3,060	3,133
1. Compensation	2,381	2,553	2,789	2,855
a. Permanent positions	2,327	2,484	2,680	2,768

The funds shown will support 103 permanent positions in 1980. The current estimate for 1979 reflects an increase over the 1979 budget estimate due to the October 1978 pay increase.

Basis of Cost for Permanent Positions

In 1980 the cost of permanent positions will be $2,768,000, an increase of $88,000 over 1979. The increase results from the following:

Cost of permanent positions in 1979		2,680
Cost increase in 1980		+131
Within grade advances and career development		
Full year effect of 1979 actions	+22	
Partial year effect of 1980 actions	+25	
Full year effect of October 1978 pay increase	+3	
Full year effect of 1979 personnel increase	+22	
Two extra workdays	+20	
Decrease in reimbursements	+39	
Cost of decreases in 1980		-43
Turnover savings and abolished positions	-29	
Full year effect of 1979 actions	---	
Partial year effect of 1980 actions	-14	
Cost of permanent positions in 1980		2,768

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
b. Nonpermanent positions				
1. Cost	49	62	101	79
2. Workyears	7	7	12	9

The increase from the 1979 budget estimate to the 1979 current estimate is due to the establishment of a part-time employment program, and the addition of two youth opportunity program positions. The 1980 estimate reflects a slight decrease as a result of absorption of the part-time program into the permanent position ceiling. The 1980 estimate will support the following programs at the levels indicated below:

Distribution of Nonpermanent Workyears by Program

Program	Workyears
Cooperative training programs	4
Youth opportunity programs	2
Other temporary employment	3
Total	9

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
c. Overtime and other compensation	5	7	8	8

The 1980 estimate of overtime is necessary to meet management and administrative requirements in such areas as procurement and financial management.

2. Benefits	242	254	271	278

The following table reflects the personnel benefits by major category:

Category of Costs				
Civil Service Retirement Fund	175	183	196	201
Employee life insurance	11	14	12	13
Employee health insurance	50	51	57	58
FICA	1	1	1	1
Incentive awards	5	5	5	5
Total	242	254	271	278

The increase from the 1979 budget estimate to the 1979 current estimate is a result of the October 1978 pay raise increase. The increase in 1980 is due to the full year effect of the 1978 pay raise.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
B. Supporting Costs	25	16	23	18
1. Transfer of personnel	10	11	15	10

The amounts estimated for 1979 and 1980 are based on the 1978 experience and planned personnel turnover.

2. Personnel training	15	5	8	8

The personnel training costs are primarily for "Upward Mobility" training for women and minorities, and EEO "Counsel Training". The increase in the 1979 current estimate over the 1979 budget estimate is due to the greater demand for upward mobility training.

TRAVEL

II. TRAVEL	84	65	92	99

Basis of Fund Requirements

A. Program Travel	53	33	55	58
B. Scientific and Technical Meeting Travel	8	---	14	15
C. Management and Operations Travel	23	32	23	26
Total, Travel	84	65	92	99
A. Program Travel	53	33	55	58

Program travel requirements are directly related to the accomplishment of the Center's mission, and will mainly be in support of the Space and Terrestrial Applications Office. The increase from the 1979 budget estimate to the 1979 current estimate is to support the Earth Resources Laboratory. The increase in 1980 reflects an increase in travel costs due to the expansion of the Regional Applications program activity in the Earth Resources Laboratory.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
B. Scientific and Technical Meeting Travel	8	---	14	15

Scientific and technical meeting travel will permit employees to participate in meetings and technical seminars with other representatives of the aerospace community. This participation allows them to benefit from exposure to technological advances outside NSTL, as well as to present both accomplishments and problems to their associates. Many of the meetings are working panels convened to solve certain problems for the benefit of the Government. The increase from the 1979 budget estimate to the 1979 current is due to increased travel related to the Earth Resources Laboratory.

C. Management and Operations Travel	23	32	23	26

Management and operations travel is used for the direction and coordination of general management matters. It includes travel in such areas as personnel, financial management, and procurement activities; travel of the Center's top management to NASA Headquarters and other NASA Centers; and local transportation. The decrease from the 1979 budget to the 1979 current reflects 1978 actual experience. The increase in 1980 is attributable to travel involving management matters concerning the Earth Resources Laboratory.

FACILITIES SERVICES

The National Space Technology Laboratories (NSTL) covers 138,807 acres and consists of a complex of facilities which include laboratories, office, and rocket engine test facilities.

The complex encompasses about 1,064,511 gross square feet of building space including seven major buildings. Also included are five major technical facilities. This physical plant supports an average daily Center population of 2,800 to 3,000 personnel. Many of the test facilities are utilized on schedules involving more than one shift and/or frequently during off-peak hours.

III. FACILITIES SERVICES	---	350	1,094	1,173
		Basis of Fund Requirement		
A. Maintenance and Related Services				
1. Facilities	---	100	100	100
Subtotal	---	100	100	100

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
B. Custodial Services	---	250	242	246
C. Utilities	---	---	752	827
Total, Facilities Services	---	350	1,094	1,173
A. Maintenance and Related Services	---	100	100	100
1. Facilities	---	100	100	100

Provides modifications and alterations of facilities for normal recurring movements of personnel and equipment of the Earth Resources Laboratory.

B. Custodial Services	---	250	242	246

Provides security guard services, janitorial services and fire protection to the Earth Resources Laboratory personnel by the National Space Technology Laboratories institutional support services contractor.

C. Utilities	---	---	752	827

Provides for the purchase of the two utility commodities; the electricity from the Mississippi Power Company; and natural gas from the United Gas Pipe Line Company. Natural gas is the primary heating fuel used at NSTL. These utilities were previously funded by the R&D appropriation. The estimated requirements for these utilities are as follows:

1. Electricity (12,560 mW/Hs)	465
2. Natural gas (181,000 K cu ft)	362

TECHNICAL SERVICES

IV. TECHNICAL SERVICES	---	50	41	41

Basis of Fund Requirements

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
A. Automatic Data Processing				
1. Operations	---	35	35	35
B. Scientific and Technical Information				
1. Library	---	15	6	6
Total, Technical Services	---	50	41	41
A. Automatic Data Processing	---	35	35	35

Provides for the supplies, materials and software programs in support of the Earth Resources Laboratory.

B. Scientific and Technical Information	---	15	6	6

Provides for the books, periodicals and other technical reports required by the Earth Resources Laboratory. The 1979 decrease reflects reassessment of requirements.

MANAGEMENT AND OPERATIONS

V. MANAGEMENT AND OPERATIONS	---	200	217	225

Basis of Fund Requirements

A. Administrative Communications	---	35	25	25
B. Printing and Reproduction	---	45	45	47

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
C. Transportation	---	35	55	56
D. Installation Common Services	---	85	92	97
Total, Management and Operations	---	200	217	225
A. Administrative Communications	---	35	25	25

Provides for the local telephone service for the Earth Resources Laboratory.

B. Administrative Printing	---	45	45	47

Provides for printing and reproduction services in support of the Earth Resources Laboratory personnel.

C. Transportation	---	35	55	56

Provides for the rental of the GSA vehicles required to support the operations of the Earth Resources Laboratory. The increase in 1979 current estimate from the 1979 budget estimate reflects a reassessment of support requirements.

D. Installation Common Services	---	85	92	97

Provides supplies, materials and equipment for the Earth Resources Laboratory. The increase in 1979 current estimate from the 1979 budget estimate is due to increased requirements for supplies and materials.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NATIONAL SPACE TECHNOLOGY LABORATORIES
DECEMBER 4, 1978

NSTL SUMMARY STAFFING

	FY 79	FY 80
Excepted	1	1
GS-16	1	1
GS-15	9	9
GS-14	10	9
All Other GS	87	87
Wage Board	0	0
Total Permanent	104	103

A reduction in FY 1979 of 2 and in FY 1980 of 1 has not yet been distributed to personnel ceilings in the internal organization structure.

OFFICE OF THE MANAGER

	FY 79	FY 80
Excepted	1	1
GS-16	1	1
All other GS	2	2
TOTAL PERMANENT	4	4

CHIEF COUNSEL

	FY 79	FY 80
GS-15	1	1
All other GS	1	1
TOTAL PERMANENT	2	2

EXECUTIVE STAFF

	FY 79	FY 80
GS-14	--	--
All other GS	6	6
TOTAL PERMANENT	6	6

RESOURCES & FINANCIAL MANAGEMENT OFFICE

	FY 79	FY 80
GS-14	1	1
All other GS	18	18
TOTAL PERMANENT	19	19

PROCUREMENT & CONTRACTS OFFICE

	FY 79	FY 80
GS-14	1	1
All other GS	11	11
TOTAL PERMANENT	12	12

FACILITIES ENGINEERING OFFICE

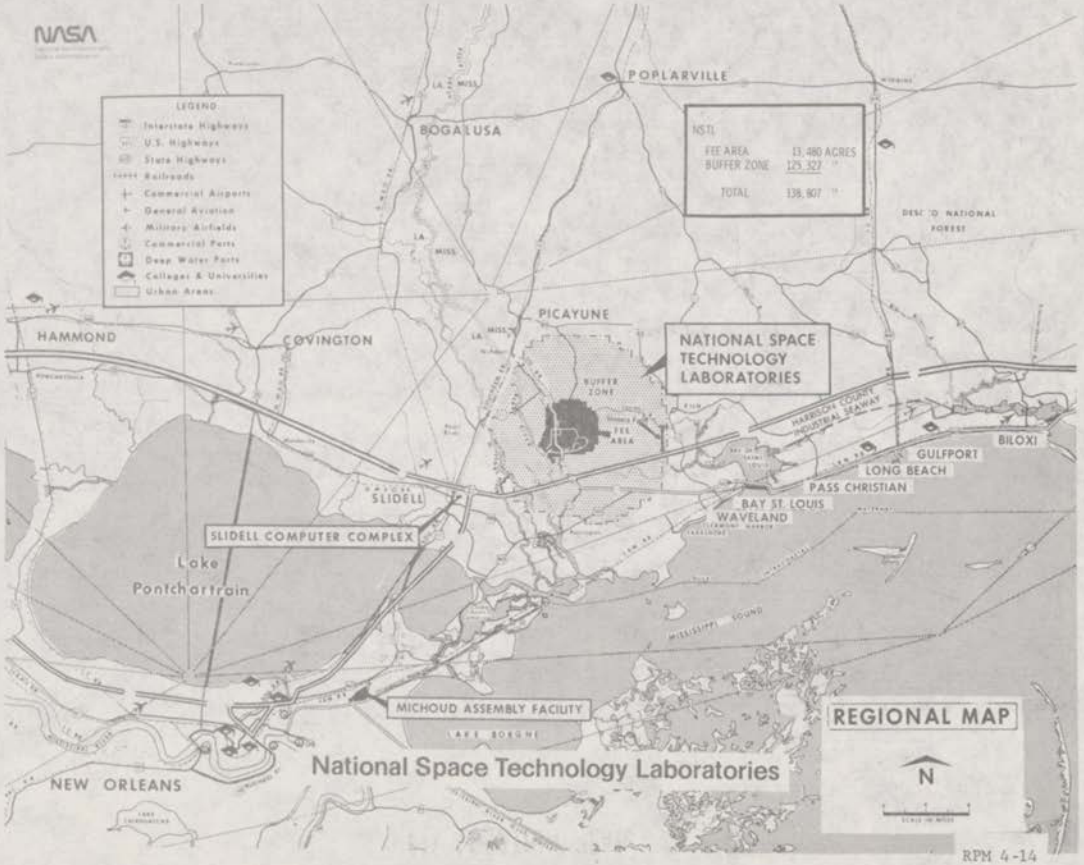
	FY 79	FY 80
GS-14	1	1
All other GS	8	8
TOTAL PERMANENT	9	9

INSTALLATIONS OPERATIONS OFFICE

	FY 79	FY 80
GS-14	2	2
All other GS	12	12
TOTAL PERMANENT	14	14

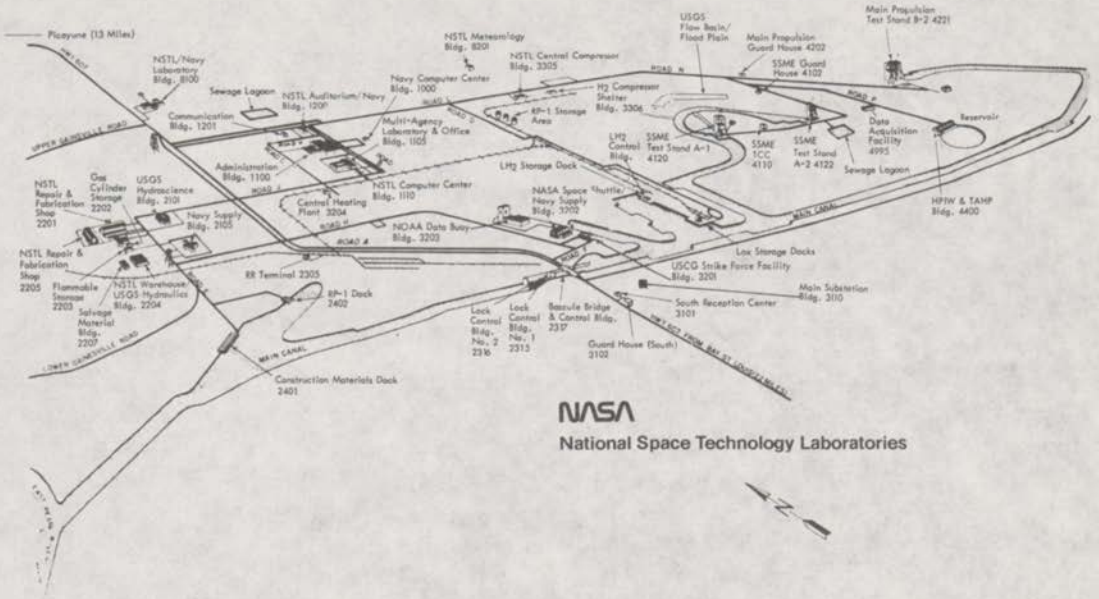
EARTH RESOURCES LABORATORY

	FY 79	FY 80
GS-15	4	4
GS-14	5	5
All other GS	31	31
TOTAL PERMANENT	40	40


NASA
LEGEND
Interstate Highways
U.S. Highways
State Highways
Railroads
Commercial Airports
General Aviation
Military Airfields
Commercial Ports
Deep Water Ports
Colleges & Universities
Urban Areas
NSTL
FEE AREA 13,480 ACRES
BUFFER ZONE 125,327 "
TOTAL 138,807 "
POPLARVILLE
BOGALUSA
PICAYUNE
HAMMOND
COVINGTON
NATIONAL SPACE TECHNOLOGY LABORATORIES
BUFFER ZONE
FEE AREA
HARRISON COUNTY INDUSTRIAL SEAWAY
BILOXI
GULFPORT
LONG BEACH
PASS CHRISTIAN
BAY ST. LOUIS
WAVELAND
SLIDELL
SLIDELL COMPUTER COMPLEX
Lake Pontchartrain
MICHOUD ASSEMBLY FACILITY
NEW ORLEANS
National Space Technology Laboratories
REGIONAL MAP
N

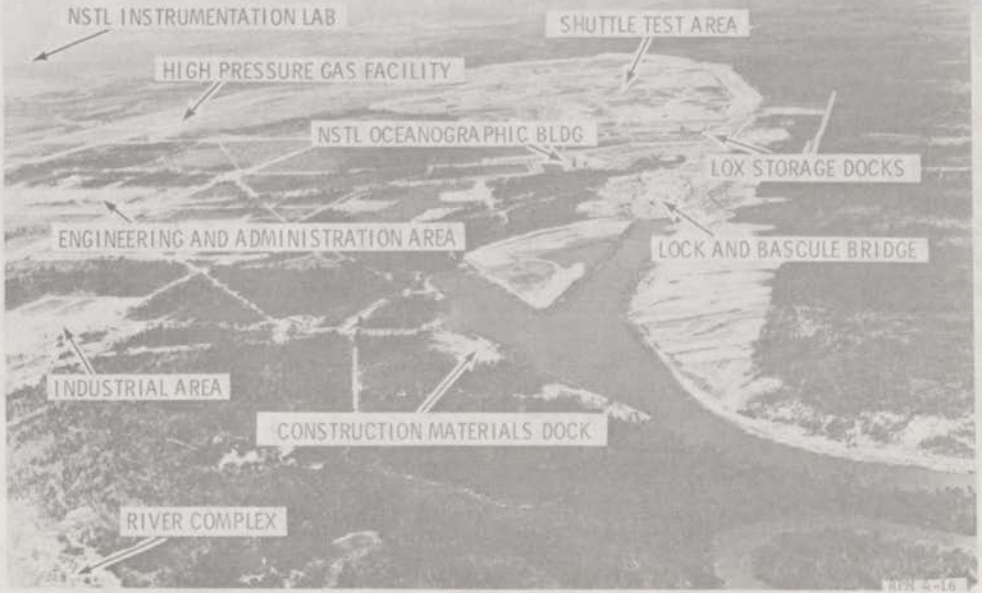
RPM 4-14

NSTL LOCATION PLAN



RPM 4-15

NATIONAL SPACE TECHNOLOGY LABORATORIES-AERIAL VIEW



RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1980 ESTIMATES

GODDARD SPACE FLIGHT CENTER

DESCRIPTION

The Goddard Space Flight Center, located 15 miles northeast of Washington, DC., at Greenbelt, Maryland, is situated on a 554-acre main site. Three additional nearby plots of 640 acres comprise the remote site area and contain the Goddard Antenna Test Range, the Goddard Optical Facility, the Propulsion Research Facility, the Magnetic Fields Component Test Facility, the Attitude Control Test Facility, and the Network Training and Test Facility. The total capital investment for the Goddard Space Flight Center, including tracking stations and contractor-held facilities at various locations as of September 30, 1978, was $701,089,000.

The majority of the Goddard Center's personnel are located at Greenbelt, Maryland; other personnel are located at the Goddard Institute for Space Studies in New York City, and throughout the world, managing the operation of satellite tracking and communications network stations.

CENTER ROLES AND MISSIONS

The Goddard Space Flight Center, established in 1959 as the first major United States installation devoted to the investigation and exploration of space, conducts a wide-ranging program in space science and applications. The Goddard Center has developed many diverse capabilities: the management of complex projects; the development of wholly integrated spacecraft, ranging from systems engineering to development, integration, and testing; the development and operation of satellite tracking networks, data acquisition and analysis; and scientific research to include both theoretical studies and the development of many significant scientif. experiments flown on satellites. The principal and supporting roles are:

PRINCIPAL

Earth Orbital Spacecraft Development and Flight Operations - for space science and applications, includes spacecraft propulsion and supporting technology such as low cost structural evaluation and reliability demonstration, advanced guidance systems and space power systems. Major emphasis is on automated, standard spacecraft systems, free flyers, experiment development and integration, and the planning and conducting of associated flight operations.

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Tracking and Data Acquisition Systems and Support Operations - planning, developing and implementing the tracking network, data processing and analysis, communications, and mission control systems and facilities. Planning and conducting support of earth orbit spacecraft. Includes flight control, tracking, data acquisition, communications, and information processing and analysis. Network planning and implementation support for Shuttle, including Orbital Flight Tests (OFT). (Tracking and data acquisition responsibilities include orbital phase acquisition of all mission types such as manned, deep space, etc.).

Spacelab Payloads - developing, analytically integrating and processing data for Spacelab payloads in astrophysics, solar terrestrial physics, astronomy, and assigned applications roles.

Space Physics and Astronomy Payloads and Science - developing the technical discipline base, including astronomical sensors; developing and implementing flight experiments, including space physics and experimentation for planetary missions.

Applications Research and Development - developing the technical discipline base, developing spaceborne sensors, developing ground data processing systems and data analysis systems, and implementing applications experiments for Environmental Observations, Resources Observations and Space Communications.

Upper Atmospheric Research - developing and applying analytical techniques, evaluating advanced instrumentation concepts for atmospheric constituent analysis, and developing concepts for future flight missions.

Information Systems Technology - developing and maintaining a technology base.

Sounding Rocket Development, Procurement and Operations - developing and procuring sounding rockets and carrying out all phases of operations from mission/flight planning to landing and recovery. Includes supporting systems (i.e., guidance, telemetry and attitude control), payload carrier development, development acquisition. (Most GSFC sounding rocket activities involve the higher performance, more complex vehicle support systems. Most activities involving lower performance vehicle systems are assigned to Wallops Flight Center (WFC)).

Launch Vehicle Procurement - for Space Science and Space Applications-oriented missions. Current focus on sounding rockets and Delta.

SUPPORTING

Planetary Science - developing and applying techniques for the analysis of planetary atmospheres.

Environmental Observations - contributing to the technical discipline base, developing spaceborne sensors and implementing experiments.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
I. Personnel and Related Costs	102,718	104,343	108,433	110,150
II. Travel	2,308	2,476	2,481	2,672
III. Facilities Services	9,897	9,895	9,560	10,288
IV. Technical Services	2,169	2,046	2,246	2,325
V. Management and Operations	6,761	5,379	5,510	5,762
Total, fund requirements	123,853	124,139	128,230	131,197

Distribution of Permanent Positions by Program

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Direct Positions				
Space Transportation Systems	132	126	119	112
Space shuttle	35	47	33	33
Space flight operations	11	10	16	17
Expendable launch vehicles	86	69	70	62
Space Science	1,111	1,066	1,108	981

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Space Science	1,111	1,066	1,108	981
Physics and astronomy	1,051	1,013	1,051	931
Planetary exploration	60	53	57	50
Space and Terrestrial Applications	784	836	802	924
Space applications	775	826	793	915
Technology utilization	9	10	9	9
Aeronautics and Space Technology	87	64	71	66
Space research and technology	86	64	71	66
Energy technology	1	---	---	---
Space Tracking and Data Systems	612	612	612	602
Tracking and data acquisition	612	612	612	602
Subtotal, direct positions	2,726	2,704	2,712	2,685
Center Management and Operations Support Positions	849	844	756	755
Total, permanent positions	3,575	3,548	3,468	3,440

PROGRAM DESCRIPTION

SPACE SHUTTLE — 33 Permanent Positions (Civil Service)

The objective of the Space Shuttle activities at Goddard Space Flight Center is to plan and implement the equipment systems, communications data, voice circuits, and operational procedures required for support during the Orbital Flight Test phase, and the subsequent operational phase of the Shuttle program.

SPACE FLIGHT OPERATIONS — 17 Permanent Positions (Civil Service)

The objective of the Goddard activities in this area is to provide the technical support and data to effectively integrate Goddard free-flyer payloads into the Space Transportation System. During 1980, Goddard will perform a variety of studies, utilizing Goddard's scientific and technical base, to better develop the Shuttle Payload requirements and interface for the Goddard free-flyer payloads. The first Shuttle Orbital Flight Test for the Office of Space Science and the first Spacelab mission for the Office of Space and Terrestrial Applications are planned to be launched in 1980.

EXPENDABLE LAUNCH VEHICLES — 62 Permanent Positions (Civil Service)

The Goddard Space Flight Center is the management center for the Delta launch vehicle. The Delta vehicle is NASA's only medium class standard launch vehicle and has the capability of accurately putting a wide variety of spacecraft into a broad spectrum of orbits, ranging from equatorial to polar inclinations. The Delta is used for NASA missions and for a wide range of reimbursable missions for other Government agencies, domestic commercial users, and international users. The Delta program is managed to provide for production of the launch vehicles required for approved missions, to provide the necessary operations support, to maintain production capability for projected missions and to provide for solid propellant upper stages and apogee booster motors. The Delta project provides engineering, quality and configuration control services to maintain operational capability with high reliability.

PHYSICS AND ASTRONOMY — 931 Permanent Positions (Civil Service)

Physics and Astronomy is comprised of research in two major areas: Astrophysics and Solar Terrestrial Research.

Goddard Astrophysics activities have the objectives of: accomplishing laboratory and flight scientific research to increase human knowledge of the earth's space environment, the stars, and other objects; and providing advanced technical development of experiments and spacecraft components for future astrophysics missions.

To this end, Goddard has organized its activities to accomplish scientific progress in all of the following discipline areas of Astrophysics: gamma ray astronomy, X-ray astronomy, ultraviolet and optical astronomy, infrared and radio astronomy, and particle astrophysics.

During 1980, Goddard's investigators will be actively involved in development of instruments and analysis of data for several major Physics and Astronomy missions; the High Energy Astronomy Observatory, the Space Telescope, the International Solar Polar Mission and the Solar Maximum Mission.

The spacecraft development will be completed and assembly started on the Dynamic Explorer. Additionally, instruments will continue to be fabricated and delivered for testing and evaluation. Government furnished equipment (GFE) for the spacecraft will be delivered to the spacecraft contractor and will include NASA Standard Tape Records, the NASA Standard Near-earth Transponder, the NASA Standard Tracking and Data Relay Satellite System (TDRSS) Transponder, and the Standard ground support equipment for these items.

In 1980, the International Ultraviolet Explorer (IUE) spacecraft with its unique satellite control and data management systems will continue to afford guest observers the opportunity to point the satellite in real time from the ground, quickly make observations, and receive data in visual formats. Additionally, it is expected that the International Sun-Earth Explorer (ISEE) series will provide unusual opportunities to study the dynamic interactions of solar wind and the earth's magnetosphere from various points in space.

In 1980, other Explorer effort will continue. It is anticipated that we will move into development of one or more of the following Explorer missions: Active Magnetospheric Tracer Experiment, Cosmic Background Explorer, or Extreme Ultraviolet Explorer.

Goddard will provide the management and support of NASA Domestic and International Sounding Rocket Programs. The project involvement stems from the conception through launch and data analysis in support of research within Galactic Astronomy, High Energy Astrophysics, Solar Physics, Plasma Physics, Aeronomy, Meteorology, Planetary Astronomy, and the applications of material space processing sciences. During 1980, we plan to introduce sounding rocket technology to the Shuttle via the mode of Experiments of Opportunity (EOP). This is a cost-effective approach which allows the experimenter to obtain scientific data from an instrument designed to fly on a sounding rocket or the Shuttle. The highlight of the year is anticipated to be the 1980 African Solar Eclipse Rocket, to be launched from San Marco off the coast of Kenya. Continued support for the Balloon scientific communities is planned, as well as the Aircraft and Climate environmental observations. Again in 1980, we anticipate the accomplishment of the development and the implementation of a logistic and technical consultation services for the Shuttle's self-contained payload containers.

PLANETARY EXPLORATION — 50 Permanent Positions (Civil Service)

The Goddard science activity within the Planetary Exploration program is designed to emphasize the physics of interplanetary space and planetary environments. To this end, Goddard will, in 1980, maintain as strong and viable a research group as is required to carry out this role.

During 1980, Goddard investigators will be actively involved in the development of two instruments, the Neutral Mass Spectrometer and the Photopolarimeter Radiometer for Project Galileo. These instruments will measure chemical composition and the physical properties of clouds in the atmosphere of Jupiter. Goddard will also be involved in the data analysis activity of various instruments on Voyager and Pioneer Venus.

SPACE APPLICATIONS — 915 Permanent Positions (Civil Service)

The Goddard Space and Terrestrial Applications program for 1980 spans this Center's broad roles and missions mandate. Included for 1980 are activities in the following discipline areas: Resource Observations, Environmental Observations, and Communications.

Goddard engages in three major types of activities in these areas: A. Space Research and Technology; B. Flight Projects; and C. Application Demonstrations. These activities may be characterized as follows:

A. The Space Research and Technology effort in general is directed toward solving major problems in the above-mentioned major applications disciplines. It stresses continuity of applied research, from the assessment of these problems, to conceptual instrument design and testing, mission and payload studies, concepts of flight missions, and their final analyses and evaluation after launch. It includes the design and construction of mathematical models to study:

1. The global circulation of this planet's atmosphere for better weather and climate prediction;

2. The dynamics of the earth to provide improved understanding of geodynamics and earthquake processes;

3. The processes of the oceans such as surface winds, waves, temperature, currents and circulation to support our weather and climate effort as well as our ocean research program;

4. The earth's resources for better monitoring, assessment, and management;

5. The use of better and advanced future communication systems; and

6. The environment of the earth's atmosphere and hydrosphere which is important for the future well being of all of us.

Other examples of efforts of more specific nature include: new instrument development for measuring temperature and pressure profiles in the atmosphere which are essential input parameters for our weather and climate models, user active and passive microwave systems for measuring sea surface temperatures, winds as well as soil moisture essential for water resources modeling and agriculture yield prediction, new instruments for ocean color measurements important for ocean studies and pollution determination, new high precision laser and electronic ranging systems to support our earth and ocean dynamics efforts, new low cost data collection platforms, and low cost global positioning system terminals for civilian application.

B. Application's Flight Project responsibilities at Goddard for 1979 and 1980 include:

1. Operational weather satellite missions for the National Oceanic and Atmospheric Administration.

   a. NOAA-B - scheduled for launch during the last quarter of 1979.
   b. NOAA-C - environmental testing is expected to be completed in the second quarter of 1980.
   c. NOAA-E Bus - structural modifications for incorporation of Search and Rescue components will be completed and delivery of the Bus will occur in the second quarter 1980.
   d. Geostationary Operational Environmental Satellite (GOES-D) - to be launched in the last quarter of 1980.

2. Landsat and Nimbus satellites extended operations - will continue to provide remotely sensed resources observations and environmental observations to a worldwide applications research science community.

3. Landsat-D - fabrication, assembly and test of the Thematic Mapper and Multispectral Scanner System instruments, observatory modules, systems and subsystems will continue, and delivery of all observatory components and subassemblies to the mission system contractor for integration and test of the first space segment will be completed by the end of 1980.

4. Magsat:

   a. Launch is scheduled for the last month of 1979.
   b. Orbital operations and data analysis will occur in 1980.

5. Applications Explorer Missions (AEM-B)/Stratospheric Aerosal and Gas Experiment (SAGE) - will continue to transmit measurements data on stratospheric aerosals and the ozone.

6. Earth Radiation Budget Experiment - proposal evaluation and award of a contract to the mission contractor, and monitoring of the design and fabrication of the instrument package are the main areas of emphasis in 1980.

7. Spinning Solid Upper Stages (SSUS-A) - to be launched in the last quarter of 1980.

C. Applications demonstration activities involve the formulation, analysis, and distribution of applications data received from satellites for which Goddard has management responsibility. Such demonstrations concern the use of data from Nimbus-7 spacecraft for the solution of problems concerning pollution, ocean resources and dynamics, and weather and climate. The Heat Capacity Mapping Mission (HCMM) will evaluate the utility of thermal measurements from satellites for determining such parameters as soil moisture and rock types inferred from surface temperatures and thermal inertia. Other examples will be the data from Landsat-3 spacecraft. This information will be of use to investigators in the agricultural, forestry, geology, land use, cartography, hydrology, ecology, and oceanography disciplines. A major activity is the transfer of Landsat data application technology to state and local government organizations, and private industry. Goddard, with the Eastern Regional Sensing Applications Center, has responsibility for remote sensing technology in 17 states.

TECHNOLOGY UTILIZATION — 9 Permanent Positions (Civil Service)

At Goddard, Technology Utilization activities are directed toward the application of space technology to public and private sector needs. Foremost among the technology applications projects in 1980 are the following:

1. New technology identification, evaluation, and publication.

2. Dissemination methods and techniques.

3. Public sector technology applications projects.

SPACE RESEARCH AND TECHNOLOGY — 66 Permanent Positions (Civil Service)

The objectives of the Goddard Space Flight Center in Space Research and Technology program activities is to provide results appropriate to space mission capability enhancement. Past efforts have produced many worthwhile advances in space system capability, reliability and effectiveness. During 1980, areas of increasing attention include cryogenics for space flight, information systems, sensors, and laser ranging.

TRACKING AND DATA ACQUISITION — 602 Permanent Positions (Civil Service)

The Tracking and Data Acquisition program at Goddard is broken into two main areas: operation of the Spaceflight Tracking and Data Network (STDN); and mission control, sensor data processing, and computation support for flight projects.

The STDN is operated in direct support of NASA's earth orbiting scientific and applications satellites and manned spaceflight programs. In addition, NASA authorizes the Network to provide services to satellites that are operated by other United States Government Agencies, such as the Department of Defense and the National Oceanic and Atmospheric Administration, by foreign governments, and by commercial companies. Appropriate segments of the Network deliver critical coverage for the launch of spacecraft that are on deep space missions by providing support during portions of the early flight path not visible to NASA's Deep Space Network (DSN).

NASA Communications Network (NASCOM) provides all operational communications required by NASA. Facilities of this Network link the stations of the STDN and will make it possible for the Tracking and Data Relay Satellite (TDRSS) to operate as a part of the overall tracking and data acquisition complex for which NASA has responsibility.

The TDRSS will provide for satellite relay of earth orbiting spacecraft data to a single ground station located at White Sands, New Mexico. The system will employ both S- and Ku-band frequencies and will greatly increase coverage capabilities available to earth orbiting spacecraft. The Network will provide the operational interface between the project users and the TDRSS. With the demonstration of a successful TDRSS, a number of STDN ground stations will be closed. However, some of the current number will be maintained to provide for launch and high altitude orbit support that cannot be provided by the TDRSS.

During 1980, the STDN is projecting support for approximately 43 missions including: Space Transportation System (STS) 1 and 2, High Energy Astronomy Observatory, Fleet Satellite Communications-4, International Sun-Earth Explorer 1, 2, and 3, International Ultraviolet Explorer, Magsat, Solar Maximum Mission, and Stratospheric Aerosol and Gas Experiment.

Mission and Data Operations provide support to flight missions in the categories of mission control, operational computing, and sensor data processing. This includes mission and systems analysis, systems design and implementation, and the operation and maintenance of multimission and dedicated technical facilities to support both Goddard and non-Goddard missions.

During 1980, increasing emphasis will be placed on defining concepts for spacecraft and data autonomy in order to modify designs of flight and ground systems to improve the response, capacity, and effectiveness of the end-to-end data system, as well as the development of system concepts and techniques to provide data to multiple users from multiple data sources. In the 1980's a new era will begin, and the practice of "customizing" support capabilities will be phased out.

In the area of mission control, the first Payload Operations Control Center Network (POCCNET) cluster will allow the reuse of standard components and designs in order to share expensive resources among a large number of missions.

For operational computing two major efforts will be undertaken. The first will be to put in place a new metric data handling system in order to provide an improved central point of metric data reception from the Space Flight Tracking and Data Network; and, the second is to size the computational requirements for the Shuttle era and provide a new computing capability for flight dynamics, including attitude computations, and command management.

As stated before, emphasis will be placed on end-to-end data concepts; and, in addition, a major effort will be required to develop and implement a new capability to process and distribute Spacelab payload data.

During this transitional phase from "customized" to multimission support, the need to provide day mission control, operational computing, and information processing support will continue to be met w. a core group of civil servants and an increasing use of contractor support through the "mission contracting" concept.

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CENTER MANAGEMENT AND OPERATIONS SUPPORT — 755 Permanent Positions (Civil Service)

Center Management and Operations Support is defined as that support or services being provided to all Goddard Space Flight Center organizations which cannot be directly identified to a benefitting program or project. The civil service personnel involved are:

Director and Staff - the Center Director, Deputy Director and immediate staff, Staff Organizations, e.g., Legal, Patent Counsel, Equal Opportunity, Planning and Analysis, Public Affairs, and Safety.

Management Support - includes a wide range of activities generally categorized as activities of a general and administrative nature which are required to operate and maintain the installation. Specific functions include resource and budget management, program control, contracting and procurement, personnel management, property management, financial management, and resource control and management information systems and analysis.

Operations Support - this is a broad spectrum of activity that is required to maintain and operate facilities, buildings, and equipment; and to provide the normal housekeeping services and logistics support for the personnel who manage and conduct the affairs of the Center. Specific activities are: maintenance and operation of all buildings and facilities, data processing and computer support, reliability and quality assurance, Centerwide security and protection, fire protection, custodial services, logistics support including transportation, supplies, etc., medical care of employees, and photographic and graphic support.

PERSONNEL AND RELATED COSTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
I. PERSONNEL AND RELATED COSTS	102,718	104,343	108,433	110,150
Basis of Fund Requirements				
A. Compensation and Benefits				
1. Compensation				
a. Permanent positions	92,141	93,060	97,064	98,441
b. Nonpermanent	656	850	831	776
c. Overtime and other compensation	626	751	738	741
Subtotal, Compensation	93,423	94,661	98,633	99,958
2. Benefits	8,576	8,904	8,960	9,290
Subtotal, Compensation and Benefits	101,999	103,565	107,593	109,248
B. Supporting Costs				
1. Transfer of personnel	165	145	192	208
2. Personnel training	554	633	648	694
Subtotal, Supporting Costs	719	778	840	902
Total, Personnel and Related Costs	102,718	104,343	108,433	110,150

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
1. Compensation	93,423	94,661	98,633	99,958
a. Permanent positions	92,141	93,060	97,064	98,441

The estimate for 1980 will support 3,440 permanent positions, a reduction of 28 from the number of positions supported in the 1979 current level. The increase from the 1979 budget estimate to the 1979 current estimate is due to the October 1978 pay raise, partially offset by a reduction in the civil service workforce.

Basis of Cost for Permanent Positions - 1980

The estimate for permanent compensation (starting from prior year cost) is based upon the position structure at the start of the year, as modified by the addition of new positions and abolishment of existing positions, within grade advances, career development, and the October 1978 pay increase. After those modifications, the year-end position structure is established and the cost effect for the year is calculated based on the estimated period that these modifications are in effect. The cost of permanent positions in 1980 will be $98,441,000, an increase of $1,377,000 over 1979. This increase is calculated as follows:

Cost of permanent positions in 1979		97,064
Cost increases in 1980		+3,547
Within grade advances and career development:		
Full year effect of 1979 actions	+1,209	
Partial year effect of 1980 actions	+1,151	
Full year effect of October 1978 pay raise	+106	
Two extra workdays in 1980	+731	
Change in reimbursables	+350	
Cost decreases in 1980		-2,170
Turnover savings and abolished positions:		
Full year effect of 1979 actions	-1,172	
Partial year effect of 1980 actions	-998	
Cost of permanent positions in 1980		98,441

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
b. Nonpermanent positions				
1. Cost	656	850	831	776
2. Workyears	77	106	84	79

The decrease in 1979 from the budget estimate to the current estimate is due to a reduction of 22 workyears. This reduction is effset by the effect of the October 1978 pay raise. The reduction in 1980 is due to the absorption of the part-time program into the permanent position ceiling. The 1980 estimate reflects the full year effect of the October 1978 pay raise and will support the following programs at the levels indicated below:

Distribution of Nonpermanent Workyears by Program

Program	Workyears
Cooperative training programs	33
Summer programs	6
Youth opportunity programs	17
Other temporary employment	23
Total	79

c. Overtime and other compensation	626	751	738	741

Overtime at Goddard is required to meet peak operational requirements where additional hours of work are essential, generally culminating in the launch of a manned or automated spacecraft. Some of the areas involved are fabrication, experimentation, testing, launching and tracking of the spacecraft. The reduction in 1979 is due to 1978 experience partially offset by the October 1978 pay raise. The level of effort in 1980 is the same as 1979.

2. Benefits	8,576	8,904	8,960	9,290

The increase from the 1979 budget estimate to the 1979 current estimate and the 1980 estimate reflects the October 1978 pay raise, partially offset by the reduction in the permanent civil service workforce.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			

The following table indicates the cost of personnel benefits by the major categories:

Category of Costs				
Civil Service Retirement Fund	6,450	6,514	6,794	6,990
Employees life insurance	313	391	342	388
Employees health insurance	1,452	1,749	1,562	1,657
Workman's compensation	92	92	92	92
FICA	20	23	22	25
Incentive awards	125	126	125	125
Other benefits	6	9	8	13
Severance pay	118	---	15	---
Total	8,576	8,904	8,960	9,290
B. Supporting Costs	719	778	840	902
1. Transfer of personnel	165	145	192	208

The category includes the reimbursement to employees of movements of household goods to the employees new duty station and other relocation expenses. The increase in 1979 from the budget estimate to the current estimate is based primarily on 1978 experience. The number of moves in 1980 is planned at the 1979 level.

2. Personnel training	554	633	648	694

The personnel training costs are based on continuation of current training programs and the need to reorient skills of employees into areas compatible with the direction of current space program and Goddard's role in the program. The increase in 1979 and 1980 is a result of the move into the Tracking and Data Relay Satellite System (TDRSS) era at GSFC. As TDRSS becomes operational, more people will have to be retrained for new jobs.

TRAVEL

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
II. TRAVEL	2,308	2,476	2,481	2,672
Basis of Fund Requirements				
A. Program Travel	1,950	2,095	2,119	2,285
B. Scientific and Technical Meeting Travel	231	232	231	247
C. Management and Operations Travel	127	149	131	140
Total, Travel	2,308	2,476	2,481	2,672
A. Program Travel	1,950	2,095	2,119	2,285

Program travel is essential to the accomplishment of the Center's mission, particularly with regard to the Physics and Astronomy, Space and Terrestrial Applications, Tracking and Data Acquisition, and Space Flight programs. In these areas, efforts will be devoted to performing applications research, developing complex satellites and launch systems, managing data processing systems, and creating scientific instruments for further research. Travel to support the Space Science, Space Tracking and Data Systems and Space Transportation Systems programs should continue in 1980 at approximately the same level experienced in 1979. Program travel in the Space and Terrestrial Applications programs is increasing, specifically, due to the Applications Explorer Mission (AEM-6), the Stratopsheric Aerosol and Gas Experiment (SAGE), and the Applications Technology Satellite (ATS).

B. Scientific and Technical Meeting Travel	231	232	231	247

Scientific and technical meeting travel permits employees to participate in meeting and technical seminars with other representatives of the aerospace community. This participation allows them to benefit from exposure to technological advances outside GSFC, as well as to present both accomplishments and problems to their associates. Many of the meetings are working panels convened to solve certain problems for the benefit of the Government. Space and Terrestrial Applications programs are the primary users of travel in this area. The level of travel in this category is expected to remain approximately the same as planned for 1979.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
C. Management and Operations Travel	127	149	131	140

Management and operations travel is used for the direction and coordination of general management matters. It includes travel in such areas as personnel, financial management, and procurement activities, travel of the Center's top management to NASA Headquarters and other NASA Centers, and local transportation. The level of travel in 1980 is expected to remain approximately the same as planned for 1979.

FACILITIES SERVICES

Goddard Space Flight Center (GSFC) is located on a 554-acre main site and on a 640-acre remote site area with a complex of laboratory and office-type buildings as well as test facilities. This complex encompasses 2,258,099 gross square feet of building space including 17 major buildings. Also included are seven major technical facilities. This physical plant supports an average daily on-Center population of 5,800 to 6,100 personnel. Many of the test facilities are utilized on schedules involving more than one shift and during off-peak hours.

III. FACILITIES SERVICES	9,897	9,895	9,560	10,288
Basis of Fund Requirements				
A. Rental of Real Property	754	795	637	647
B. Maintenance and Related Services				
1. Facilities	1,710	1,371	1,482	1,504
2. Equipment	38	14	15	16
Subtotal	1,748	1,385	1,497	1,520
C. Custodial Services	2,379	1,750	1,842	1,972
D. Utility Services	5,016	5,965	5,584	6,149
Total, Facilities Services	9,897	9,895	9,560	10,288

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	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
A. Rental of Real Property.....	754	795	637	647

This provides space for personnel at certain tracking stations and the Goddard Institute of Space Sciences (GISS) in New York City, as well as storage and warehouse space for equipment, supplies and materials. The decrease in 1979 from the budget estimate to the current estimate is due to a reduction in actual space rented. The area requirements in 1980 are approximately the same as those rented in 1979.

B. Maintenance and Related Services.....	1,748	1,385	1,497	1,520
1. Facilities.....	1,710	1,371	1,482	1,504

The 1978 actual and 1979 current estimate are higher than the 1979 budget estimate because of increases in the level of maintenance at GSFC due to the exceptionally harsh winter of last year. The majority of the maintenance involves repair of sidewalks and curbs, repaving of roads and roof repairs. Some of the emergency maintenance scheduled in 1978 has been deferred until 1979. It is estimated that 1980 levels will be comparable to 1979.

This activity provides in 1980 for the continuation of the same level of effort as in 1979. The major services included are:

a. Maintenance and operation..... 458

These funds provide general buildings maintenance including painting, inspection, and mechanical and electrical maintenance.

b. Ground maintenance..... 167

Provides for mowing, cultivation, mulching, fertilizing and care of trees and shrubs.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
c. Supplies and facilities equipment				403

Included in this category are chemicals, building materials, electrical and electronic materials, general maintenance and operating materials, metals, pipes, valves, and fittings.

d. Routine facilities work				476

Included in this activity is support for rehabilitation and modification of facilities, office alteration and safety upgrading.

2. Equipment	38	14	15	16

Provides for maintenance of and equipment for the onsite radio communications network. The effort is level from 1979 and 1980 and contains no large equipment procurements as in 1978.

C. Custodial Services	2,379	1,750	1,842	1,972

This activity involves a total of 117 support contract workyears of effort at GSFC. The increase from the 1979 budget estimate to the current estimate is due to support contractor wage rate increases. The level of services provided in 1980 will be the same as required for 1979.

1. Janitorial services (78 workyears of effort)				1,160

This activity is applicable to about 2.2 million square feet of area, and includes washing and relamping of light fixtures, office cleaning, minor laundry services, and trash removal.

2. Security guard services (39 workyears of effort)				812

This activity includes badging of all onsite personnel and visitors, vehicle identification, and protection of all Government facilities and equipment including the GISS in New York City.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
D. Utilities Services	5,016	5,965	5,584	6,149

The estimate provides for operation and maintenance of the utility plant and distribution systems as well as the purchase of utility services, and supplies, materials and equipment required for the maintenance of these systems. Electricity is purchased from Potomac Gas and Electric Company, natural gas from Washington Gas Light Company and fuel oil from a local supplier, Water and sewage is provided by the Washington Suburban Sanitary Commission. Included is $237,000 for utility system maintenance, $326,000 for utilities provided to leased buildings, and $5,586,000 for the purchase of utilities services as follows:

1. Electricity (94,000 MW/Hrs)	4,351
2. Natural Gas (165,000 K cu. ft.)	601
3. Fuel Oil (1 million gals.)	353
4. Water and Sewage	281

TECHNICAL SERVICES

IV. TECHNICAL SERVICES	2,169	2,046	2,246	2,325

Basis of Fund Requirements

A. Automatic Data Processing				
1. Equipment	255	276	276	280
2. Operations	1,000	893	1,010	1,070
Subtotal	1,255	1,169	1,286	1,350

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
B. Scientific and Technical Information				
1. Library	405	553	568	576
2. Education and Information	297	102	213	217
Subtotal	702	655	781	793
C. Shop Support and Services	212	222	179	182
Total, Technical Services	2,169	2,046	2,246	2,325
A. Automatic Data Processing	1,255	1,169	1,286	1,350

This funding provides accounting and management information to satisfy requirements of NASA and GSFC management. Included is support of GSFC business data functions.

1. Equipment	255	276	276	280

The maintenance costs ($114,000) of all GSFC-owned administrative ADP equipment and the lease costs ($166,000) of all leased administrative ADP hardware are included in this estimate. Leased equipment includes Xerox 1200 printer, Sycor terminal system, various other terminals, and other peripheral equipment. Maintenance services are provided for the IBM 360/50 (main business computer), memory disc drives, terminals, and associated equipment. Costs remain essentially level from year-to-year.

2. Operations	1,000	893	1,010	1,070

The systems supported include Institutional Management, Financial and Accounting, Procurement, and Personnel Management. The increase in 1979 from the budget estimate to the current estimate, and the increase from 1979 to 1980 is due to support contractor wage increases. The current estimate in 1979 and 1980 are more reflective of 1978 experience. Computer programming, keypunching operators, and other support personnel are provided for 36 workyears at a cost of $804,000. Supplies, materials, and software programs are included as operational costs for provision of administrative ADP information ($266,000).

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
B. Scientific and Technical Information.....	702	655	781	793

These funds provide for the operation of a technical library at GSFC, a public affairs educational and informational program, and support to the Center in the provision of various scientific and technical information services.

1. Library.....	405	553	568	576

Cataloging, reference, acquisition, and translating services, and distribution of books and publications in the operation of the GSFC library are funded in this estimate. This includes over 65,000 books, 45,000 journals, plus almost one million microfiche copies of aerospace documents.

2. Education and information.....	297	102	213	217

This estimate includes funds for exhibit management and refurbishment, spacemobile operation, demonstrational models, workshops and symposia, and educational and informational materials. Funding was added in 1979 for the Visitor's Center exhibits and special weather/climate films, which was not originally included in the 1979 budget estimate.

C. Shop Support and Services.....	212	222	179	182

Support is provided in the areas of safety, photo services, graphics, and publications. Fire protection system maintenance and related supplies and equipment; film and print processing, photographic supplies and repair of photographic equipment; art work services and related supply and equipment costs; and materials and equipment maintenance for compilation of documents comprise this category. The level of funding for 1980 is essentially unchanged from 1979.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
V. MANAGEMENT AND OPERATIONS	6,761	5,379	5,510	5,762
Basis of Fund Requirements				
A. Administrative Communications	2,261	2,475	2,264	2,299
B. Printing and Reproduction	331	384	311	316
C. Transportation	1,458	1,652	1,690	1,845
D. Installation Common Services	2,711	868	1,245	1,302
Total, Management and Operations	6,761	5,379	5,510	5,762
A. Administrative Communications	2,261	2,475	2,264	2,299

Provides for local telephone service, long distance telephone service, and other non-telephone communications. The decrease from the 1979 budget estimate to the current estimate is due to the recategorization of postage into the Installation Common Services function. The same level of support is projected for 1980 as in 1979.

1. Local telephone services 1,240

Covers 3,600 PBX internal lines and 5,800 telephone instruments at GSFC; there are 13 tielines for Baltimore-area communications. An additional 225 General Services Administration (GSA) centrex lines are used for computer data operations.

2. Long distance telephone service 938

a. Federal Telecommunications System use will approximate 700,000 calls in 1980, at a level based on the 1978 actual.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		

b. Tolls or commercial long distance costs are included.

3. Non-Telephone communications..... 121

a. Teletype costs including the GSA Automatic Records System (ARS).

b. Also included is a United Press International Wire Service for the Public Affairs Office.

B. Printing and Reproduction..... 331 384 311 316

This estimate provides the funding for an onsite printing plant operated by GSFC personnel. This printing plant produces approximately 17,000,000 units of printing each year. In addition to this onsite printing plant, GSFC must also purchase from private firms under Government Printing Office contract, about 30,000,000 units of printing each year. This purchased printing is a combination of an overflow requirethat cannot be handled because of the onsite workload and items that cannot be handled with the onsite equipment. Types of printing accomplished by offsite private firms are multiple-copy forms, multicolor work, and forms for computer use. The decrease in 1979 from the budget to the current estimate is due to a reduction of xerox maintenance costs. Costs are essentially level from 1979 to 1980.

C. Transportation..... 1,458 1,652 1,690 1,845

Involves 51 workyears of support contractor effort for the operation of Center transportation and storage areas, and other miscellaneous services. Also included are supplies and equipment for vehicle maintenance, gasoline, contracted services for vehicle maintenance, and special vehicle rental. The 1980 increase is caused by the full year effect of negotiated support contractor wage rates.

1. Contractor support provides the following services:

a. Operation of Transportation Center--33 workyears for drivers, dispatchers, supervisory personnel; provide pickup and delivery of purchased items and stock items, mail delivery, shuttle transportation, issuance of motor pool vehicles.

b. Packing and crating--one workyear for preparing shipments.

c. Rigging--three workyears for rigging equipment for relocation on the Center for shipment elsewhere.

d. Tape storage--six workyears to operate central magnetic tape depository.

e. Storage and warehousing--seven workyears to operate receiving areas for supplies, stock issuance, and warehousing and storage function.

f. Moving and hauling--one workyear for moving equipment and furniture on emergency basis.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
D. Installation Common Services	2,711	868	1,245	1,302

Supports Center management and staff activities, provides medical services, and covers various installation support services. The increase in 1979 from the budget estimate to the current estimate is due to the addition of postage previously included in the communications function. Also the medical support service contractor increased by three workyears to provide radiological services at GSFC. The 1980 level of effort remains the same as in 1979.

1. Center management and staff..... 164

Includes patent searches and applications; steno services, handbook revisions, Equal Opportunity programs; and general administrative supplies, materials, equipment, and equipment maintenance (microfilm, copiers, special typewriters) for staff offices.

2. Medical Services..... 661

Provides support in Occupational Medicine and Environmental Health. Eighteen support contractor workyears are required for onsite support.

a. Occupational medicine..... 414

This activity consists of operation of the GSFC onsite health unit and medical services for GISS employees in New York. Fifteen workyears provide emergency care onsite, annual physical exams for GSFC employees, fitness programs, immunizations, and counseling. Annual physical exams are provided for approximately 3,400 employees at the Center. The necessary supplies, materials and equipment for operation of the health unit are included.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		

b. Environmental health..... 247

Environmental health consists of industrial hygiene and an environmental health lab at a total of three workyears for detection and correction of health hazards. Necessary supplies, materials, and equipment are included.

3. Installation support services..... 477

This estimate includes all administrative support items not specifically identified elsewhere. Among these are the purchase of office furniture and operating supplies issued from stock; maintenance of all Center labor-saving devices; materials for mailroom and warehouse operation; and postage costs.

a. Office supplies..... 129

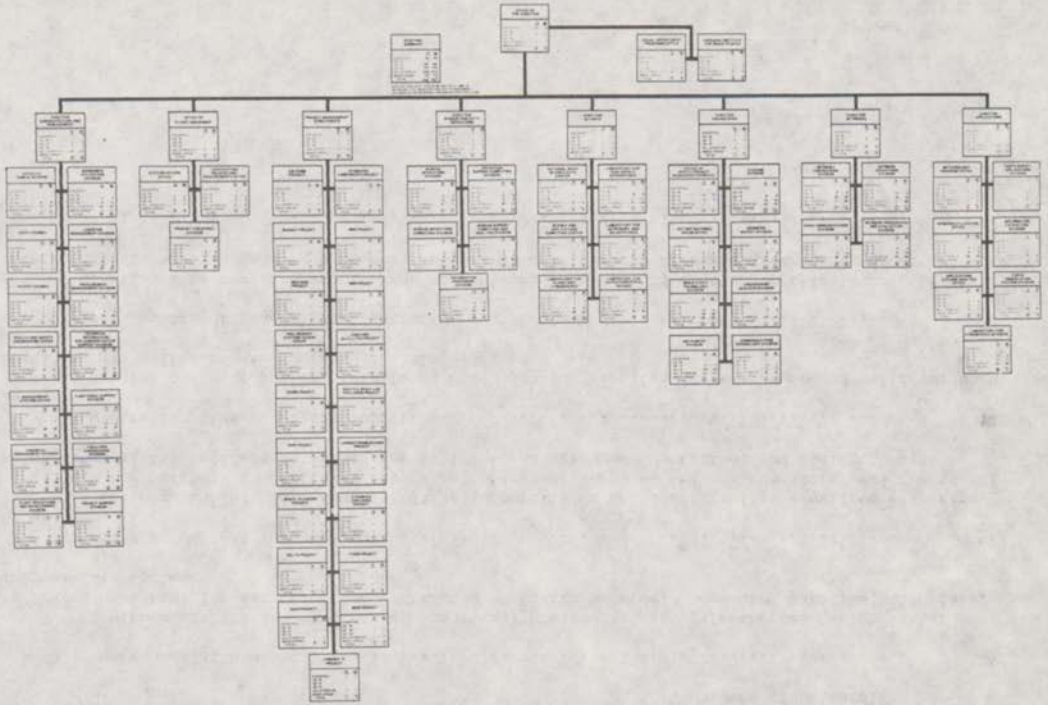
General office supplies, furniture, and operating supplies for warehouse and mailroom, such as pallets and gas cylinders are included in this estimate.

b. Maintenance of general administrative equipment..... 72

This funding provides maintenance of copiers, time stamps, electronic calculators, electric typewriters, calculators, and adding machines; as well as cylinder and electric file maintenance.

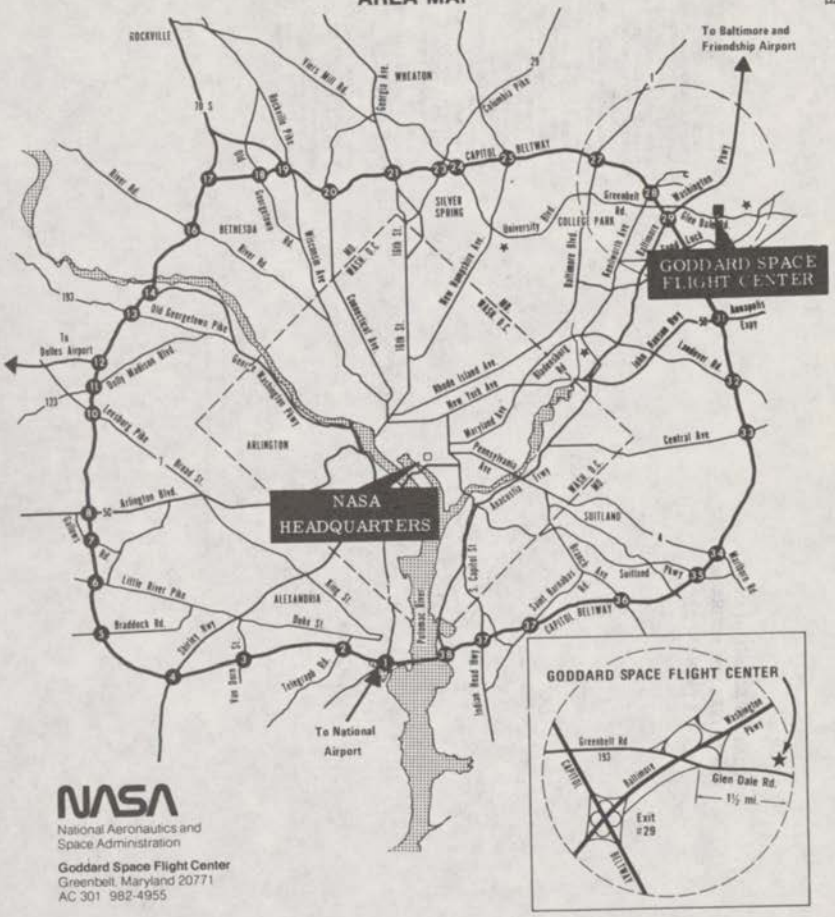
c. Postage..... 276

GODDARD SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
ORGANIZATION AND STAFFING SUMMARY



GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1980 ESTIMATES
AREA MAP

RPM 5-28



NASA
National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771
AC 301 982-4955

GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1980 ESTIMATES
LOCATION PLAN

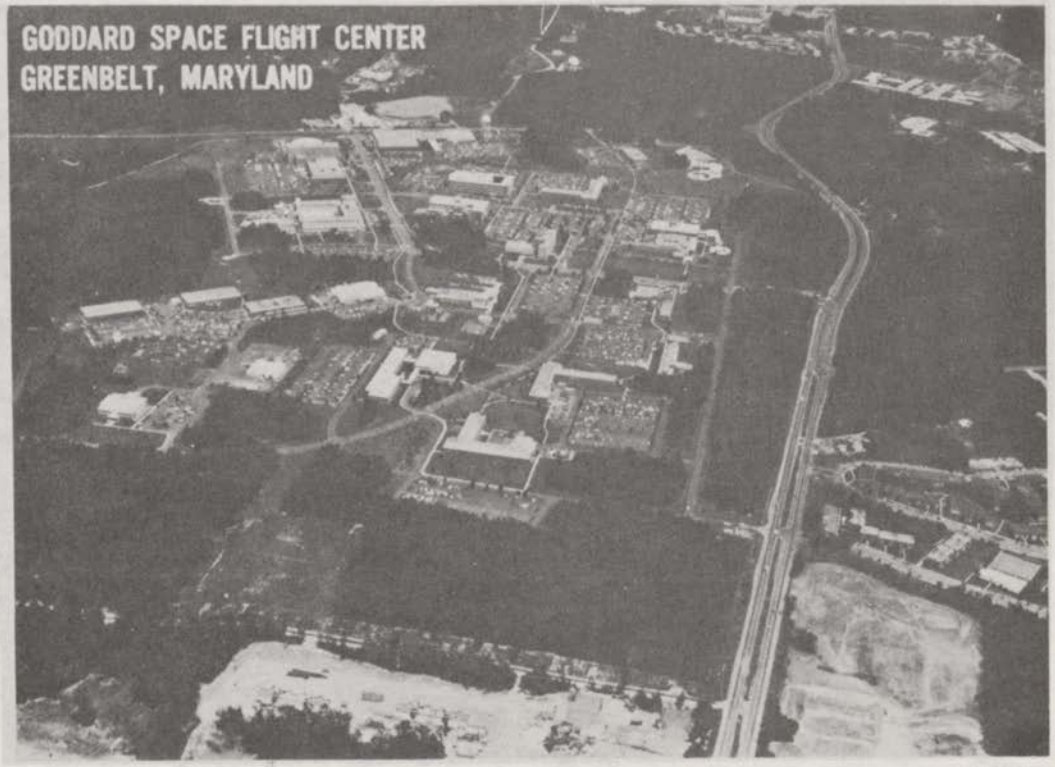


1 SPACE PROJECTS BUILDING
2 RESEARCH PROJECTS LABORATORY
3 CENTRAL FLIGHT CONTROL & RANGE OPERATIONS BUILDING
4 GENERAL PURPOSE FACILITY BUILDING
5 INSTRUMENT CONSTRUCTION & INSTALLATION LABORATORY
6 SPACE SCIENCES LABORATORY
7 PAYLOAD TESTING FACILITY
8 SATELLITE SYSTEMS BUILDING
9 MAIN GATE HOUSE
10 ENVIRONMENTAL TESTING LABORATORY
11 APPLIED SCIENCES LABORATORY
12 TRACKING & TELEMETRY LABORATORY
14 SPACECRAFT OPERATIONS FACILITY
15 LAUNCH PHASE SIMULATOR
16 DEVELOPMENT OPERATIONS BUILDING
17 MULTI-PURPOSE BUILDING
18 BUSINESS OPERATIONS BUILDING
19 MULTI-PURPOSE BUILDING
20 GEOCHEMISTRY BUILDING
21 METEOROLOGICAL SYSTEMS DEVELOPMENT LABORATORY
22 MECHANICAL TEST FACILITY & QUALITY ASSURANCE LABORATORY
23 DATA INTERPRETATION LABORATORY
24 CENTRAL HEATING & REFRIGERATION PLANT
25 NETWORK TRAINING & TEST FACILITY
26 NASA SPACE SCIENCE DATA CENTER
27 MOBILE EQUIPMENT SUPPORT FACILITY
28 TECHNICAL PROCESSING FACILITY
29 FREQUENCY STANDARD AND TEST FACILITY
86 DAY CARE CENTER BUILDING
87 GAS CYLINDER STORAGE BUILDING
88 VISITOR'S CENTER
97 PLANT MAINTENANCE SUPPORT FACILITY
98 GEWA STORE
99 NASA CAREER DEVELOPMENT CENTER

◇ — TECHNICAL PROCESSING FACILITY - FY78 PROJECT
◇ — NETWORK CONTROL CENTER FACILITY - FY78 PROJECT
◇ — MODIFICATIONS & ADDITIONS FOR LOGISTIC & SUPPLY FUNCTIONS - FY78 PROJECT
◇ — SPACELAB DATA PROCESSING FACILITY - FY80 PROJECT

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RPM 5-30

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1980 ESTIMATES

WALLOPS FLIGHT CENTER

DESCRIPTION

Wallops Flight Center includes three separate areas on the Atlantic Coast of Virginia's Eastern Shore: the main base, the Wallops Island launching site, and the Wallops mainland site. The administrative offices, range control center, support shops, and main telemetry buildings are located on the main base. Wallops Island is about seven miles southeast of the main base and is connected to the mainland by a causeway and bridge. The island is about five miles long and one-half mile wide at its widest point. Located on the island are rocket storage buildings, blockhouses, assembly shops and launch sites. The Wallops mainland site is a one-half mile strip west of the island which houses the radar and optical tracking sites.

Wallops Flight Center, totalling 6,166 acres, consits of 1,833 acres on the main base, 3,085 acres on Wallops Island, 108 acres on the mainland tracking site, and 1,140 acres of marsh land. The total capital investment, including fixed assets in progress and contractor-held facilities at various locations as of September 30, 1978, was $136,678,000.

CENTER ROLES AND MISSIONS

Wallops Flight Center prepares, assembles, launches, and tracks space vehicles and acquires scientific information from them. Wallops also has developed, maintains, and operates a research airport in support of NASA's aeronautical research programs which include projects associated with airport-aircraft interface, air traffic control, avionics systems technology, final approach and landing systems, airport configuration, high speed turn-off techniques, airport environmental studies, noise reduction technology, and general aviation research focused on aircraft spin characteristics, cross-wind landings, pilot performance, and procedures and aides at uncontrolled airports and airspace. Its facilities are utilized by the scientists and engineers from the laboratories and research centers of NASA, other governmental agencies, colleges and universities, and the worldwide scientific community. Center personnel assist these scientific research teams with their projects and develop, as necessary, special types of instrumentation and equipment to complete the mission.

The principal and supporting roles are:

PRINCIPAL

Sounding Rocket Development, Procurement and Operations - developing and procuring sounding rockets and carrying out all phases of operations, from mission and flight planning to landing and recovery. Payload carrier development, telemetry, experiment management support to other institutions, launch operations, and tracking and data acquisition are included.

Balloon Program - managing, monitoring, scheduling, and technical analysis of balloon activities conducted for NASA, the Office of Naval Research and the National Science Foundation.

SUPPORTING

Sounding Rocket Payload Carrier Development and Experiment Management Support - provided in the applications disciplines of weather and climate.

Aeronautical Flight Test Support - provide flight test support for Langley Research Center's aeronautical flight test programs, including tracking and data acquisition.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
I. Personnel and Related Costs	9,978	10,313	10,521	10,749
II. Travel	316	348	372	406
III. Facilities Services	2,796	2,959	3,100	3,398
IV. Technical Services	405	449	346	524
V. Management and Operations	1,525	1,136	1,154	1,253
Total, fund requirements	15,020	15,205	15,493	16,330

Distribution of Permanent Positions by Program

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Direct Positions				
Space Transportations Systems	4	6	3	---
Space flight operations	---	2	---	---
Expendable launch vehicles	4	4	3	---
Space Science	70	67	70	67
Physics and astronomy	70	67	70	67
Space and Terrestrial Applications	56	45	53	56
Space applications	55	44	52	55
Technology utilization	1	1	1	1
Aeronautics and Space Technology	34	27	34	34
Aeronautical research and technology	34	27	34	34
Space Tracking and Data Systems	109	98	107	108
Tracking and data acquisition	109	98	107	108
Subtotal, direct positions	273	243	267	265
Center Management and Operations Support Positions	134	165	131	130
Total, permanent positions	407	408	398	395

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PHYSICS AND ASTRONOMY — 67 Permanent Positions (Civil Service)

Sounding Rocket Program

The objective of this program is to support space research, using low cost sounding rockets, in the fields of Solar Physics, Galactic Astronomy, Fields and Particles, and Ionospheric Physics. Wallops Flight Center provides flight systems support, launch range support, and support to experiments utilizing sounding rockets.

In 1980, the Wallops Launch Range will provide launch activities and ground instrumentation/support of the launches at Wallops Flight Center and at the Poker Flats Research Range near Fairbanks, Alaska, plus expedition type support to other areas. The Wallops Flight Center launch range is equipped with launchers capable of handling sounding rockets of all sizes. The Poker Flats Research Range is jointly supported by Wallops Flight Center and the Defense Nuclear Agency, which has limited capability, although its facilities can be supplemented by the mobile equipment from Wallops Flight Center.

Balloon Program

The objective of this program is to support space research, using low cost balloon platforms, in the fields of Solar Physics, Galactic Astronomy, Stratospheric Composition and Aeronomy.

In 1980, Wallops Flight Center will provide ground instrumentation support, technical, and flight hardware support to experimenters in the balloon program.

The majority of the flights are conducted from the National Scientific Balloon Facility site at Palestine, Texas, or the United States Air Force site at Holloman, New Mexico; however, some flights are supported from remote sites in the northern United States, Canada, Alaska, Australia, New Zealand, Argentina and Brazil.

SPACE APPLICATIONS — 55 Permanent Positions (Civil Service)

Environmental Observation

In 1980, the Wallops Flight Center civil service personnel will continue to conduct the Meteorological Rocket Network project. The objectives of this project are:

1. To investigate the processes which characterize the physical state of the strato-mesosphere region of the atmosphere and to determine interactions within this layer of the atmosphere and with the troposphere.

2. To provide data for climatology of the upper atmosphere.

3. To provide in-situ measurement data which are used to calibrate satellite remote sensors.

Through the Meteorological Rocket Networks project, Wallops Flight Center manages NASA's participation in the Cooperative Meteorological Rocket Network (CMRN), the Experimental Inter-American Meteorological Rocket Network (EXAMETNET) and the Eastern-Western Hemisphere Meteorological Rocket Network.

In Ocean Processes, where the primary emphasis is being placed, investigations in the broad areas of sea state measurement, surface currents, ocean topographical mapping, and their supporting ground truth, studies are in progress.

In 1980, the Wallops Flight Center civil service personnel will be involved in investigating the feasibility of determining ocean surface currents from satellites and aircraft measurement of the local surface wave structure; investigating the "sea state bias effect" in satellite altimetry to develop methods of correcting the error; determining the mean sea surface of geoid; evaluating and determining the inadequacies of existing predictive and descriptive synoptic ocean circulation models and investigating the impact of utilizing synoptic altimeter data as input to the models; and developing techniques of using altimeter pulse wave form data for the determination of sea state.

Balloon Program

The objective of this program is to support the Space and Terrestrial Applications program using low cost balloon platforms in the field of stratospheric composition, meteorology and aeronomy.

TECHNOLOGY UTILIZATION — 1 Permanent Positions (Civil Service)

In 1980, this civil servant will carry out the Technology Utilization program at WFC, and be involved in (1) expediting application of new technology, (2) encouraging the use of NASA technology in other sectors, and (3) understanding more fully the technology transfer process and its impact.

AERONAUTICAL RESEARCH AND TECHNOLOGY — 34 Permanent Positions (Civil Service)

In 1980, the Wallops Flight Center airport will be involved in conducting research tests of various aircraft and helicopters in the terminal area operating environment. Flight studies will be made of new approach and landing procedures utilizing the latest in guidance equipment and techniques, pilot information displays, vertical and short takeoff and landing flight vehicles, helicopter stablization, terminal area navigation, and tests of other systems leading to automatic landing of aircraft. One runway has been modified to study the effect of runway grooving as a means of controlling aircraft hydroplaning on wet or slush-covered runways. Studies of automotive

hydroplaning have also been conducted using this runway. The data acquired from the aircraft and automotive tests will utimately assist in the development of safer, more flexible transportation systems.

TRACKING AND DATA ACQUISITION — 108 Permanent Positions (Civil Service)

Tracking and data acquisition activities provide both fixed and mobile equipment for tracking, data acquisition, and communications. These activities will encompass the acquisition of new systems, modifications and updating of existing systems and the operation, maintenance, and repair of these instrumentation systems. Included are highly precise instrumentation radars, analog and digital telemetry systems, precise range timing systems, range intercommunication systems, radio communication systems, tracking laser systems, digital data transmission systems, command and control systems, and digital data processing systems. These instrumentation systems are used in support of both aeronautical and rocket launched flight projects. These flight projects are conducted at Wallops Flight Center or at off-range locations in various parts of the world, depending upon the scientific experiment requirements. The sounding rocket programs supported at Wallops will cover all of the atmospheric and space disciplines in which research is undertaken, utilizing a family of launch vehicles varying in size and power from the small meteorological rockets to the 72-foot Scout with orbital capability. In 1980, more than 300 sounding rockets are to be launched from Wallops Island and remote sites around the world, carrying experiments in the fields of Aeronomy, Energetic Particles, Ionospheric Physics, Meteorology, and Solar Physics.

Of particular interest is the current effort to measure the effect of aerosols on the protective layer of ozone in the upper atmosphere which filters out harmful solar radiation.

CENTER MANAGEMENT AND OPERATIONS SUPPORT — 130 Permanent Positions (Civil Service)

Center Management and Operations Support is defined as the support of services being provided to all Wallops Flight Center organizations which cannot be directly identified to a benefitting R&D program or project. The civil service personnel involved are:

Director and Staff

The Center Director, Deputy Director and the immediate staff, e.g., Legal, Patent Counsel, Equal Opportunity, Planning and Analysis, Public Affairs and Safety.

Management Support

Includes a wide range of activity categorized as management support for programs and functional organizations for the entire Center. Specific functions include resource and budget management, program control, contracting and procurement, personnel management, property management, financial management, resource control and management information systems and analysis.

Operations Support

This is a broad spectrum of activity that is required to maintain and operate facilities, buildings, and equipment; and to provide the normal housekeeping services and logistics support for the personnel who manage and conduct the affairs of the Center. Specific activities are:

Maintenance and operation of all buildings and facilities
Data processing and computer support
Reliability and quality assurance
Center-wide security and protection
Fire protection
Custodial services
Logistics support including transportation, supplies, etc.
Medical care of employees
Photographic and graphic support

PERSONNEL AND RELATED COSTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
I. PERSONNEL AND RELATED COSTS	9,978	10,313	10,521	10,749
Basis of Fund Requirements				
A. Compensation and Benefits				
1. Compensation				
a. Permanent positions	8,698	8,964	9,096	9,299
b. Nonpermanent	173	208	251	251
c. Overtime and other compensation	160	157	173	173
Subtotal, Compensation	9,031	9,329	9,520	9,723

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
2. Benefits	900	943	956	981
Subtotal, Compensation and Benefits	9,931	10,272	10,476	10,704
B. Supporting Costs				
1. Transfer of personnel	11	6	10	10
2. Personnel training	36	35	35	35
Subtotal, Supporting Costs	47	41	45	45
Total, Personnel and Related Costs	9,978	10,313	10,521	10,749
A. Compensation and Benefits	9,931	10,272	10,476	10,704
1. Compensation	9,031	9,329	9,520	9,723
a. Permanent Positions	8,698	8,964	9,096	9,299

The funds shown above will support 395 permanent positions in 1980. The cost increase from the 1979 budget estimate to the 1979 current estimate is due to the October 1978 pay raise, partially offset by the reduction in civil service positions.

Basis of Cost for Permanent Positions

In 1980, the cost of permanent positions will be $9,299,000 an increase of $203,000 from 1979. This increase results from the following calculation:

Cost of permanent positions in 1979		9,096
Cost increase in 1980		+355
Within grade advances and career development:		
Full year effect of 1979 actions	+76	
Partial year effect of 1980 actions	+75	
Full year effect of 1979 pay increases	+45	
Two extra paid days in 1980	+71	
Decrease in reimbursements	+88	
Cost decrease in 1980		-152
Turnover savings and abolished positions:		
Full year effect of 1979 actions	-114	
Partial year effect of 1980 actions	-38	
Cost of permanent positions in 1980		9,299

Other Compensation Costs

b. Nonpermanent positions

1. Cost	173	208	251	251
2. Workyears	22	29	32	29

The increase from the 1979 budget estimate to the 1979 current estimate is due to cost of the October 1978 pay raise, an increase in the cooperative training program and the implementation of the experimental part-time program. The 1980 plan includes 29 workyears which is about the same as 1979 except for the absorption of the part-time program into the permanent position ceiling and will support the following programs at the levels indicated below:

Distribution of Nonpermanent Workyears by Program

Program	Workyears
Cooperative training programs	14
Summer programs	5
Opportunity programs	8
Other temporary employment	2
Total	29

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
c. Overtime and other compensation	160	157	173	173

Overtime funds are required at Wallops primarily to meet operational requirements of the sounding rocket programs of the Physics and Astronomy and Space Applications programs. Many factors beyond the Center's control, such as launch schedules, weather holds, and range clearance problems necessitate work beyond normal hours to operate the launch facilities, provide instrumentation support, and conduct tracking and data acquisition activities required to assure mission sucess. The increase from the 1979 budget estimate to the 1979 current is due to the October 1978 pay raise and the Eclipse Program requirements.

2. Benefits	900	943	956	981

Following are the amounts of contribution by category:

Category of Costs				
Civil Service Retirement Fund	616	636	655	669
Employee life insurance	40	43	43	44
Employee health insurance	223	241	237	247
Workmen's Compensation	13	13	13	13
FICA	3	5	3	3
Incentive awards	4	2	4	4
Other benefits	1	3	1	1
Total	900	943	956	981

The current estimate for 1979 is increased over the budget estimate due to the October 1978 pay raise, partially offset by the reduction in civil service positions. The 1980 increase reflects the full year effect of the pay raise and higher cost for health insurance, which are partially offset by the savings from the manpower reductions.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
B. Supporting Costs	47	41	45	45
1. Transfer of personnel	11	6	10	10

The transfer of personnel costs in 1979 and 1980 will cover the expenses for one permanent change of station move planned each year.

2. Personnel training	36	35	35	35

The estimates for personnel training provide for costs of the Wallops Flight Center engineering technician apprentice program. Because of its remote location, Wallops historically has had difficulty recruiting qualified engineers and engineering technicians. Estimates remain essentially level from year to year.

TRAVEL

II. TRAVEL	316	348	372	406
Basis of Fund Requirements				
A. Program Travel	148	164	196	210
B. Scientific and Technical Meeting Travel	44	46	47	51
C. Management and Operations Travel	124	138	129	145
Total, Travel	316	348	372	406

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
A. Program Travel	148	164	196	210

Program travel is directly related to the accomplishment of the Center's mission and reflects the continuing effort in the procurement and launch activities, the sounding rocket development program, the balloon program, and the aeronautical flight test program. The increase from the 1979 budget estimate to the 1979 current estimate is due to increased travel requirements as a result of the eclipse expedition in February 1979 and more planned foreign travel.

B. Scientific and Technical Meeting Travel	44	46	47	51

Scientific and technical meeting travel permits employees to participate in meetings and technical seminars with other representatives of the aerospace community. This participation allows them to benefit from exposure to technological advances outside WFC, as well as to present both accomplishments and problems to their associates. Many of the meetings are working panels convened to solve certain problems for the benefit of the Government.

C. Management and Operations Travel	124	138	129	145

Management and operations travel is used for the direction and coordination of general management matters. It includes travel in such areas as personnel, financial management, and procurement activities; travel of the Center's top management to NASA Headquarters, and other NASA Centers; and local transportation. The increase in 1980 reflects the provision for cost of negotiated wage increases in the intra-center transportation contract.

FACILITIES SERVICES

Wallops Flight Center involves 6,166 acres and a complex of facilities which mainly consist of research, airport, and launch operations facilities. This complex encompasses 1,053,264 gross square feet of building space including three major buildings. Also included are three major technical facilities. This physical plant supports an average daily on-Center population of 900 to 1,100 personnel housed on site. Many of the test facilities are utilized on schedules involving more than on shift and/or frequently during off-peak hours.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	Budget Estimate
		(Thousands of Dollars)		
III. FACILITIES SERVICES	2,796	2,959	3,100	3,398
Basis of Fund Requirements				
A. Maintenance and Related Services				
1. Facilities	871	966	946	1,072
2. Equipment	47	48	48	52
Subtotal	918	1,014	994	1,124
B. Custodial Services	604	653	669	718
C. Utilities Services	1,274	1,292	1,437	1,556
Total, Facilities Services	2,796	2,959	3,100	3,398
A. Maintenance and Related Services	918	1,014	994	1,124
1. Facilities	871	966	946	1,072

This activity, requiring 38 workyears of effort, provides for the maintenance, repair and alteration of over 300 buildings and one million square feet of building space on 6,166 acres of land. The corrosive environment at Wallops Flight Center, caused by its proximity to the ocean, requires frequent maintenance and repair of exterior surfaces, roofing, utility distribution systems, mechanical doors, hardware and building equipment. The increase in 1980 over 1979 is for negotiated support contractor wage increases. Major types of support in this area are:

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		

a. Ground maintenance..... 377

Approximately 18 workyears provide for maintenance of lawns, trees and shrubs, and for snow removal.

b. Maintenance and operations..... 349

Twenty workyears provide for the maintenance and operation of over 300 buildings.

c. Supplies and equipment..... 346

Provides for the replacement of supplies necessary to the operation of the Wallops facility.

2. Equipment.....	47	48	48	52

Provides for the maintenance of miscellaneous equipment at the Center.

B. Custodial Services.....	604	653	669	718

Provides for 44 workyears of support service contractor effort for janitorial services, firefighting and ambulance service, and plant security. Also provides for refuse removal, pest control and other miscellaneous services. The increases in 1979 and in 1980 are for negotiated support contractor wage increases.

1. Janitorial Services..... 288

Twenty workyears provide for the cleaning of buildings.

2. Firefighting and plant security..... 350

Twenty-four workyears provide for firefighting, ambulance, and security guard service.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
3. Miscellaneous				80

Provides for refuse removal, pest control, laundry and other miscellaneous services.

C. Utilities	1,274	1,292	1,437	1,556

The only purchased utilities at Wallops Flight Center are electricity and fuel oil to operate the heating plant. This funding also provides for 10 support contract workyears to operate and maintain the heating plant. Since the 1979 budget estimate, utility consumption figures have been revised. The increase in 1979 from the budget to the current estimate is due to increased utility rates. The activity consumption decreased during the same period. In 1980, there is a further decrease in consumption offset by increasing rates. The increase in 1980 is due to utility rate and negotiated support service contract wage increases. The purchased utilities are as follows:

1. Electricity (16,400 MWH)	715
2. Fuel Oil (1,382 K Gal.)	635

TECHNICAL SERVICES

IV. TECHNICAL SERVICES	405	449	346	524

Basis of Fund Requirements

A. Automatic Data Processing				
1. Equipment	40	11	10	14
2. Operations	99	69	108	118
Subtotal	139	80	118	132

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
B. Scientific and Technical Information				
1. Library	82	108	92	104
2. Education and information	23	223	32	175
Subtotal	105	331	124	279
C. Shop Support and Services	161	38	104	113
Total, Technical Services	405	449	346	524
A. Automatic Data Processing	139	80	118	132

Provides for administrative data processing including equipment maintenance, programming and operation. Seven workyears of support contractor effort are budgeted for this activity. The increase from the 1979 budget estimate to the 1979 current estimate reflects the level of operations effort provided in 1978. The increase in 1980 is to provide for higher equipment maintenance cost and negotiated support contract wage increases.

1. Equipment 14

Provides for annual maintenance of remote terminals and peripheral equipment used for administra- data processing.

2. Operations 118

Seven workyears provide programming and operation of equipment used for processing of necessary business data such as payroll and other fiscal records, procurement, and personnel and supply data.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
B. Scientific and Technical Information.....	105	331	124	279

Includes the purchases of books, supplies, and materials for, and the operation of the Wallops Flight Center Technical Library. It also provides for public information services, and for the exhibits, and operation of a visitor information center. The 1980 estimate provides for the new visitor information center.

1. Library..... 104

Three workyears are used to operate the library. The procurement of books, subscriptions, supplies and materials are also covered.

2. Education and Information..... 175

One workyear of support contractor effort is used to provide tour guide services for visitors. Provision is also made for the cost of exhibits and the operation of the soon to be constructed Visitor Information Center (VIC) at Wallops Flight Center and for miscellaneous other public information services. The completion of the VIC will take place in 1980.

C. Shop Support and Services.....	161	38	104	113

Three workyears of support contractor effort will be used to provide engineering and fabrication support for facility planning and alteration. The increase from the 1979 budget estimate to the 1979 current estimate reflects a re-evaluation of engineer support required.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
V. MANAGEMENT AND OPERATIONS	1,525	1,136	1,154	1,253
Basis of Fund Requirements				
A. Administrative Communications	123	149	126	136
B. Printing and Reproduction	77	75	84	86
C. Transportation	69	79	73	80
D. Installation Common Services	1,256	833	871	951
Total, Management and Operations	1,525	1,136	1,154	1,253
A. Administrative Communications	123	149	126	136

Provides for the operation of the Wallops Flight Center's main switchboard and teletype facility, for the cost of leased lines and long distance tolls, and for maintenance services. The decrease from the 1979 budget estimate to the 1979 current estimate is due to the transferring of postage from the administrative communications function to the installation common services function. The increase from 1979 to 1980 is to cover the cost of negotiated support contract wage increases.

1. Local telephone service 130

Five workyears are required to operate the Wallops Flight Center main switchboard and teletype facility. Provision is also made for maintenance and repair services. The increase from 1979 to 1980 is due to negotiated contractor wage increases partially offset by a decrease of 1 workyear.

2. Long distance telephone service 6

Covers the cost of leased lines and long distance tolls.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
B. Printing and Reproduction	77	75	84	86

Provides for five workyears of support service contractor effort to operate the printing and reproduction facility at Wallops Flight Center. Costs are essentially level from year to year. The increase from the 1979 budget estimate to the 1979 current estimate reflects a continuation of 1978 cost rates for a full year.

C. Transportation	69	79	73	80

Includes the cost of commercial off-base services and repairs to the government owned motor vehicle fleet; the maintenance and repair of the Wallops Flight Center Queen Air aircraft; and freight and related transportation costs.

1. Transportation of things..... 3

Covers the cost of freight charges, and costs related to local moves, i.e., drayage and parcel post.

2. Maintenance and repair of vehicles..... 30

Provides for commercial services and repairs to the government-owned motor vehicle fleet.

3. Maintenance and repair of aircraft..... 47

Provides for approximately one workyear of contractor effort and for parts and supplies required to maintain the Wallops Flight Center Queen Air aircraft.

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	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
D. Installation Common Services.....	1,256	833	871	951

Provides for medical services, rental of copying machines, supplies, materials and equipment used for administrative purposes, supply management, materials handling and postage. The increase from the 1979 budget estimate to the 1979 current estimate reflects the transferring of postage from administrative communications to this function. The increase from 1979 to 1980 is for negotiated support contract wage increases and higher prices for supplies and equipment.

1. Medical Services..... 26

Provides for the part-time services of a medical doctor's support of the Wallops Flight Center Occupational Health Program.

2. Machine Rental..... 156

Covers the rental of copying equipment.

3. Supplies and Equipment..... 317

Provides for supplies, materials and equipment necessary for the administrative functions at Wallops Flight Center.

4. Supply Management..... 421

Twenty two workyears provide for moving and materials handling and operating the supply system at Wallops Flight Center.

5. Postage..... 31

Covers the cost of the Center's postal bill.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WALLOPS FLIGHT CENTER

SUMMARY STAFFING	79	80
EXCEPTED	2	2
GS-16	1	1
GS-15	12	11
GS-14	28	27
ALL OTHER GS	314	313
WAGE BOARD	41	41
TOTAL PERMANENT	398	395

A REDUCTION IN FY 1979 OF 9 AND IN FY 1980 OF 3 HAS NOT YET BEEN DISTRIBUTED TO PERSONNEL IN THE INTERNAL ORGANIZATION STRUCTURE.

DIRECTOR	79	80
EXCEPTED	2	2
GS-16	-	-
GS-15	3	3
GS-14	-	-
ALL OTHER GS	3	3
WAGE BOARD	-	-
TOTAL PERMANENT	8	8

OPERATIONS DIRECTORATE	79	80
EXCEPTED	-	-
GS-16	-	-
GS-15	3	3
GS-14	6	5
ALL OTHER GS	111	111
WAGE BOARD	2	2
TOTAL PERMANENT	122	121

ENGINEERING DIRECTORATE	79	80
EXCEPTED	-	-
GS-16	1	1
GS-15	4	4
GS-14	12	12
ALL OTHER GS	75	75
WAGE BOARD	-	-
TOTAL PERMANENT	92	92

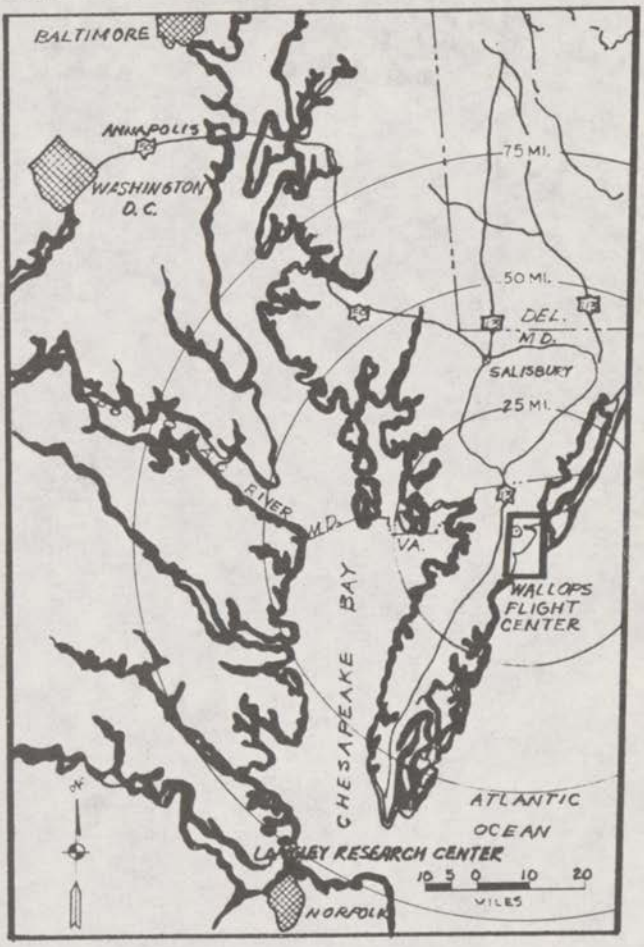
ADMINISTRATION DIRECTORATE	79	80
EXCEPTED	-	-
GS-16	-	-
GS-15	1	1
GS-14	2	2
ALL OTHER GS	72	72
WAGE BOARD	-	-
TOTAL PERMANENT	75	75

TECHNICAL SUPPORT DIRECTORATE	79	80
EXCEPTED	-	-
GS-16	-	-
GS-15	-	-
GS-14	1	1
ALL OTHER GS	56	58
WAGE BOARD	34	32
TOTAL PERMANENT	91	91

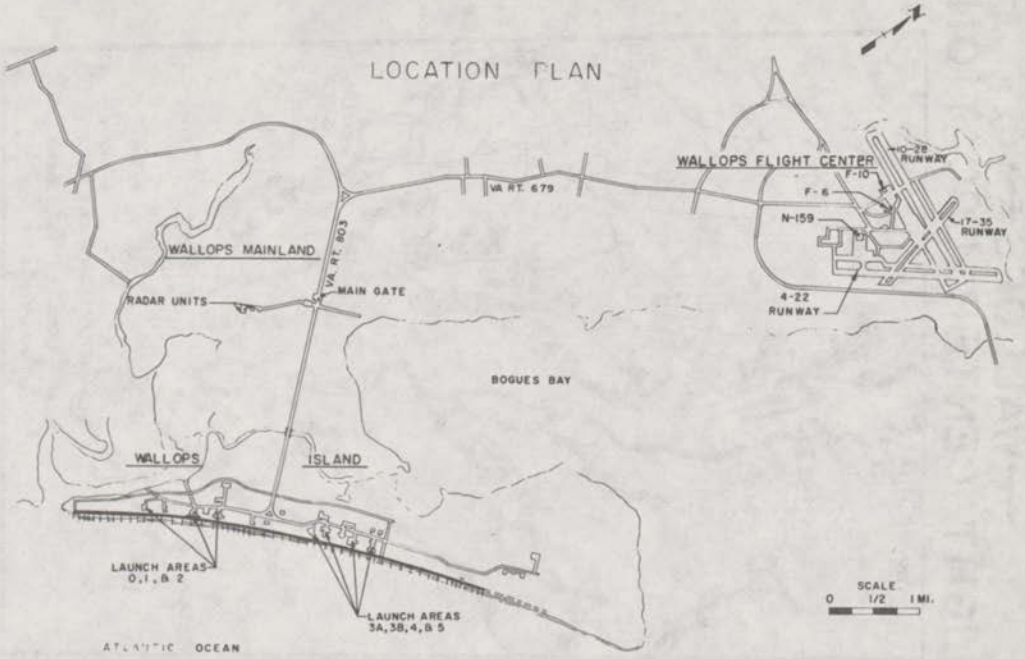
APPLIED SCIENCE DIRECTORATE	79	80
EXCEPTED	-	-
GS-16	-	-
GS-15	1	1
GS-14	8	8
ALL OTHER GS	11	11
WAGE BOARD	-	-
TOTAL PERMANENT	20	20

—WALLOPS—
FLIGHT CENTER LOCATION

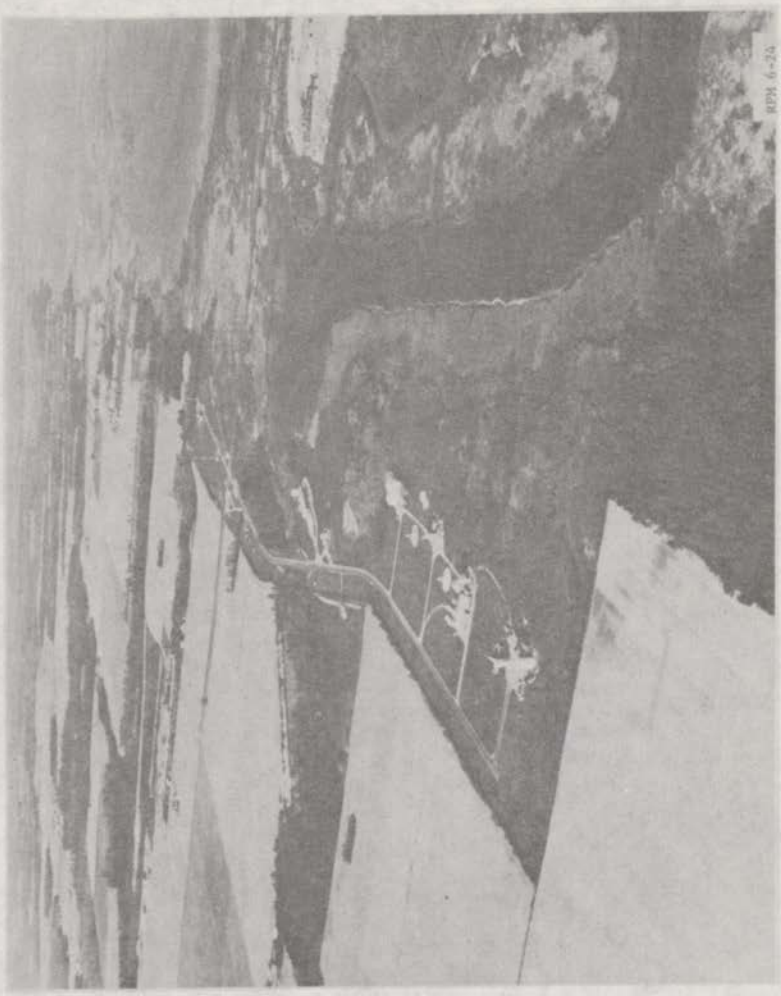
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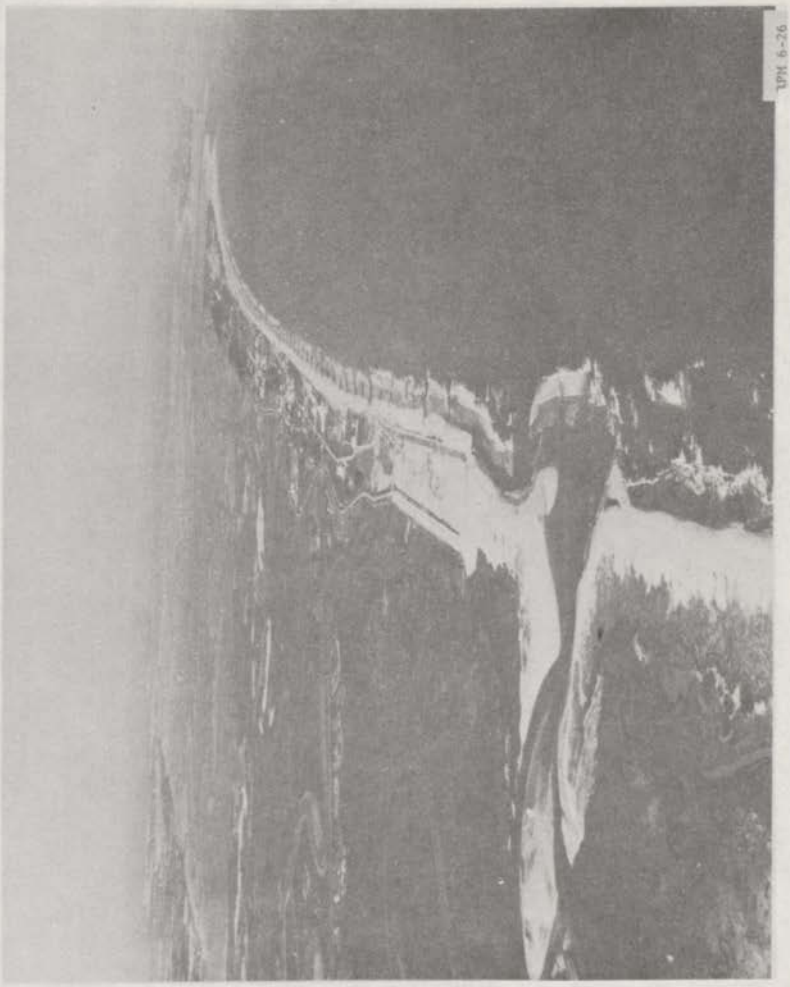
WALLOPS FLIGHT CENTER



RPM 6-23


RPM 6-24




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RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1980 ESTIMATES

AMES RESEARCH CENTER

DESCRIPTION

The Ames Research Center (ARC) is located on 421 acres at the southern end of San Francisco Bay on land contiguous to the U.S. Naval Air Station, Moffett Field, California. Certain facilities, such as the utilities and airfield runways, are used jointly by NASA and the Department of the Navy. Also housed at ARC is the U.S. Army Research and Technology Laboratory. Personnel from this laboratory work closely with Ames personnel on research of mutual interest. The capital investment at the ARC, including fixed assets in progress and contractor-held facilities at various locations, as of September 30, 1978 was $377,163,000.

CENTER ROLES AND MISSIONS

The programs at the Ames Research Center involve research and development in the fields of aeronautics, space science, life science, and space technology, as well as applications to national needs of the new science and technology growing out of the aerospace program. Specifically, the Center's major program responsibilities are concentrated in: short-haul aircraft technology, rotorcraft technology, flight simulation, computational fluid dynamics, planetary probes, airborne sciences and applications, aeronautics and biological space life sciences. In addition to these major program responsibilities, the Center provides support for military programs, and various civil aviation projects. The principal and supporting roles are:

PRINCIPAL

Fundamental Aerodynamics - advancing the general state of the art, both theoretical and experimental.

Short-Haul Aircraft Technology - developing a technology base for facilitating incorporation of short-haul aircraft into overall air transportation systems.

Rotorcraft Technology - developing a technology base for improving efficiency and flexibility for both civil and military use.

Computational Fluid Dynamics - furthering the state of the art through the definition of new systems, both hardware and software, and application to aeronautical and other related areas.

Flight Simulation - improving the state of the art to permit more effective use of simulators in aircraft design and validation-of-flight simulation.

Military Support - provision of technical support to military aviation in areas consistent with other ARC aeronautics roles and unique ARC capacilities.

Airborne Research and Applications - operating instrumented jet aircraft for the purpose of conducting airborne research and applications experiments.

Planetary Probes - developing thermal protection systems required for planetary atmosphere entry probes and managing probe development.

Planetary Mission Operations and Data Analysis - completing mission operations and data analysis for the currently approved Pioneer series.

Life Sciences:

Human-Vehicle Interactions - furthering the state of the art through the study of man-machine and other human factor interactions and considerations involved in aircraft operations.

Biomedical Support Systems - developing advanced technology for development of long duration life support systems and protective systems.

Biological Experiments - developing and conducting experiments for determining effects of space flight on (non-human) living organisms and for providing information applicable to solving space medicine problems.

SUPPORTING

Space Transportation Passenger Selection Criteria - development and evaluation of medical criteria for non-crew passenger selection.

Astronomical Observation Techniques - focus on airborne research and the development of infrared techniques and supporting systems for use in Spacelab payloads.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
I. Personnel and Related Costs	48,214	49,377	52,584	53,514
II. Travel	1,101	1,230	1,218	1,313
III. Facilities Services	5,093	5,309	6,675	7,439
IV. Technical Services	621	607	686	909
V. Management and Operations	2,701	2,689	2,598	2,664
Total, fund requirements	57,730	59,212	63,761	65,839

Distribution of Permanent Positions by Program

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Direct Positions				
Space Transportation Systems	---	3	---	---
Space flight operations	---	3	---	---
Space Science	370	369	368	324
Physics and astronomy	125	102	125	90
Planetary exploration	107	116	105	96
Life sciences	138	151	138	138

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Space and Terrestrial Applications	78	75	77	112
Space applications	72	69	72	107
Technology utilization	6	6	5	5
Aeronautics and Space Technology	801	797	802	801
Aeronautical research and technology	645	618	655	658
Space research and technology	155	179	147	143
Energy technology	1	---	---	---
Subtotal, direct positions	1,249	1,244	1,247	1,237
Center Management and Operations Support Positions	420	433	419	416
Total, permanent positions	1,669	1,677	1,666	1,653

PROGRAM DESCRIPTION

PHYSICS AND ASTRONOMY — 90 Permanent Positions (Civil Service)

Ames concentrates its physics and astronomy activities in the field of infrared astronomy, taking the agency lead in this discipline.

In 1980, the civil service personnel will provide support for the airborne astronomy program which includes a C-141 aircraft--the Kuiper Airborne Observatory--as well as a Lear Jet aircraft, and measurements using selected instruments on the Ames U-2 aircraft. These aircraft are operated by Ames as flying astronomical observatories with the bulk of the observing accomplished by various University research teams. Ames supports these facilities with its in-house science competence and with its in-house capability to operate research aircraft.

Infrared astronomy observations from space platforms avoid obscuration caused by the Earth's atmosphere. Ames has responsibility for instruments to accomplish these observations including development of the telescope portion of the Infrared Astronomical Satellite (IRAS) and definition of an advanced instrument for use on Spacelab missions.

PLANETARY EXPLORATION — 96 Permanent Positions (Civil Service)

These civil service personnel are required in 1980 to accomplish the ongoing programs in support of agency goals in planetary exploration. This program consists of a continuing series of project management activities, backed by the scientific expertise of principal investigators from Ames, other NASA Centers and the University community. An in-house supporting research and technology program serves both to maintain the Center's scientific and technological expertise and to provide the stimulus and definition for new planetary missions.

In 1980 the civil service personnel will continue to provide project management and scientific support for: (1) Pioneers 6-9, a series of spacecraft exploring the physics of the interplanetary medium and providing ongoing data on the plasma in which the Earth is immersed; (2) Pioneers 10 and 11, two spacecraft that made close approaches to the planet Jupiter to study both the planet itself and the interaction of the solar wind with the planet's strong magnetic field (these spacecraft were then retargeted by being swung in the Jovian gravity field to explore completely unexplored regions of the solar system); (3) Pioneer Venus, launched in 1978; and (4) the Galileo project, approved in 1978, a natural outgrowth of the Pioneer Venus atmospheric probes. Ames has responsibility for the Probe portion of this mission.

Ames researchers are playing key roles in all of these missions, and Ames scientists are responsible, as principal investigators, for measuring the characteristics of the solar wind in interplanetary space and near Jupiter; for measuring the atmospheric structure on Mars, Venus and Jupiter; for measuring atmospheric radiation balance on Venus and Jupiter; for measuring cloud characteristics on Venus and Jupiter, and for studying Mars for possible life-bearing soils and compounds. Ames researchers are also responsible for synthesizing atmospheric models for these planets that can be used to explain their current state and evolution and that can be applied in comparative studies to understand features of the Earth's weather and climate.

Ames principal investigators and their coworkers maintain an active program of laboratory and theoretical studies to develop basic atmospheric modeling concepts, to obtain the necessary physical data on a molecular scale to interpret the spacecraft observations, and to develop new and improved scientific measurements and instrument concepts for use on spacecraft. This program concentrates on planetary atmospheres, and has been particularly active in combining radiative transfer concepts with aerosol physics to obtain comprehensive planetary cloud and dust models.

LIFE SCIENCES — 138 Permanent Positions (Civil Service)

In 1980, the civil service personnel will continue to be involved in research, hardware development, and program management related to meeting program milestones in the areas of understanding the effects of space flight on humans and other life forms; managing non-human biological experiments in space; developing advanced life support concepts and systems; and understanding the origin, evolution, and distribution of life and life-related chemicals on Earth and elsewhere in the universe. Examples of specific 1980 activities follow:

Space flight simulation studies will continue, with testing of 55- to 65-year-old female subjects in 1980, in the program to understand and develop countermeasures for the physiological stresses of Shuttle flight so that spaceflight can eventually be made available to all interested people regardless of age or sex. The value of biofeedback training for minimizing space motion sickness symptoms will be intensively investigated.

Full development of non-human biological experiments selected and approved for flight on life sciences Spacelab missions is expected. Specimen holding units for Spacelab will be in final test just prior to delivery in early 1981. Analysis of the data and specimens from the next joint US/USSR Cosmos biosatellite, to be flown in late 1979, will occur.

Low-cost manufacturing techniques will be demonstrated for advanced space suit limb and joint components as part of the advanced life support systems research program.

Research in the origin and distribution of life and life-related molecules will be highlighted by: the formulation of a testable model for photochemical synthesis of organic compounds in Jupiter's atmosphere; the experimental testing of computer-generated models of primitive self-replicating systems; and the demonstration of the analytical capability of a miniaturized gas chromatograph for analyses of simulated Saturn and Jupiter atmospheres.

SPACE APPLICATIONS — 107 Permanent Positions (Civil Service)

The Center provides a research and applications development capability in support of the Agency's Space Applications program.

A diversified group of capable people is required to support future programs in applications including space, atmospheric, and stratospheric programs; to provide skilled personnel and specialized airborne platforms in support of the Agency's applications satellite programs; to provide skilled personnel to interpret and process both spaceborne and airborne remotely sensed data; to provide knowledgeable personnel to interact with and disseminate data and associated processing techniques to the user community.

The Center fulfills this role by: (1) defining, developing, and evaluating potential satellite sensors, data acquisition and processing techniques, and associated communications technology; (2) conducting an active and continuing broad program of applied research and developments of remote and in-situ sensing technology for earth resources applications; (3) conducting applications demonstration projects in cooperation with Federal, state, regional and local government agencies and private industry to promote the effective transfer of applications technology as well as to reduce system costs, increase adaptation to the users systems, and improve compatibility with other information sources and products routinely used by the using organization; and (4) systematically transferring, primarily to state and local governments in the 14 western states including Alaska and Hawaii, the ability to effectively use Landsat data for their resource management and planning decisions through the Western

Regional Remote Sensing Applications Center. Ames controls a variety of aircraft, some of which serve as national and international facilities for research in astronomy, geophysics, meteorology, and resources observations; others acquire data for remote sensing projects and provide a mechanism for integration of spaceborne, airborne, and ground-based data acquisition and processing systems.

Both the high altitude (U-2) and medium altitude (CV-990) aircraft provide significant support to LANDSAT (underflight data), Nimbus-7 (Ocean Color Scanner radiometer), and Heat Capacity Mapping (Heat Capacity Mapping radiometer) satellite programs.

The Ames upper atmospheric research program is an integrated activity that blends the expertise of the Center and University scientists both in the development of computer models for the upper atmosphere and in the measurement of statospheric constituents and properties from aircraft platforms. Computer modeling of the stratosphere is being performed at Ames to understand the unperturbed stratosphere and to predict the effects on the stratosphere of various pollutants, such as aircraft emissions and fluorocarbons, and of natural events such as the solar cycle and solar storms.

TECHNOLOGY UTILIZATION — 5 Permanent Positions (Civil Service)

The Technology Utilization program at Ames is a community undertaking involving the part-time efforts of scientists and engineers in many disciplines and in many Center organizations working under the leadership and coordination of a small full-time Technology Utilization Office staff. This program transfers knowledge developed from the NASA programs to industry and the public sector.

AERONAUTICAL RESEARCH AND TECHNOLOGY — 658 Permanent Positions (Civil Service)

In 1980, the content of the Ames program in aeronautics is characterized in terms of three elements: Generic Research and Technology, Vehicle Specific Technology (Short-haul, Rotorcraft) and aeronautical support to other agencies and to industry. These three elements form a coherent and interdependent program to meet the Vertical Short Take-Off and Landing (VSTOL) and rotorcraft milestones of reduced aircraft noise, improved terminal area safety and efficiency and improved performance.

Generic Research and Technology:

The Generic Research and Technology program at Ames has as its principal focus in the areas of computational aerodynamics, experimental methods, avionics, and safety. The program is concentrated in the disciplines of aerodynamics and aeroelasticity, flight dynamics, guidance and control, and human factors. The program provides the fundamental disciplinary advances, both theoretical and experimental, that extend the state of the art. Substantial progress is anticipated in our ability to compute the theoretical behavior of aerodynamic and propulsive flows and to measure experimental aircraft configurational parameters. In 1980, research programs

in flight dynamics will define the important interrelationships between vehicle dynamics, stability and control, and handling qualities in the regime of hover, and in transition from vertical to horizontal flight, for advanced VSTOL aircraft and rotorcraft. In guidance and control, the use of optimal control theory in conjunction with dynamic modeling of aircraft and ground-based guidance aids will provide new insight into the definition of air traffic control algorithms, particularly for the terminal area.

In 1980, the human factors program will provide the knowledge relevent to defining a more efficient aviation system through the better match of man and computer information transfer and decision making responsibility.

Vehicle Specific Technology Short-Haul:

The Vehicle Specific Technology at Ames is focused on short-haul aircraft, both civil and military; Rotorcraft, VSTOL and Short-Range Conventional Take-Off and Landing (CTOL) aircraft. These aircraft have generally similar characteristics including: a dependence on propulsive lift (in addition to aerodynamic lift), a greater capability for versatile operations in the terminal area, and a greater degree of integration of man and machine. The vehicle technology emphasis at Ames relates to and depends on the basic capabilities and the aeronautical research disciplines described previously. In 1980, the aeromechanics portion of the program will include small-scale and large-scale wind tunnel testing of advanced rotor concepts and complete configuration modeling and ground-based simulation, and flight research utilizing a spectrum of vehicles acquired as part of the decision to consolidate full-scale hardware testing at Ames. This class of aircraft is dependent on high lift technology and low cost guidance and control systems, both of which are part of the ongoing program at ARC. The program includes wind tunnel and simulation investigations to achieve a significantly improved short-haul transport aircraft concept and compatible low cost avionics.

Other Agency and Industry Support:

The Ames Research Center has traditionally received requests from other agencies from the industry for test support of their aircraft and systems development programs. The Navy and NASA have agreed to a comprehensive technical support program for the Navy VSTOL aircraft technology developments. The Army Research and Technology Laboratories of the U.S. Army Aviation Research and Development Command (AURADCOM) is located at Ames. The Aeromechanics Laboratory, the primary investigator of Army helicopter flight dynamics and controls, is also located at Ames, working both on independent R&D projects and with a staff integrated into the NASA organization on projects of joint interest. Extensive use is made of Ames aeronautical research facilities in these efforts. There are also a large number of joint programs with the Air Force Systems Command.

SPACE RESEARCH AND TECHNOLOGY — 143 Permanent Positions (Civil Service)

In 1980, the number of civil service personnel requested will provide a Space Research and Technology program which encompasses both fundamental research and project support. The basic research focuses on entry technology and materials research. The project work supports the Space Shuttle, Galileo, Infrared Astronomical Satellite (IRAS) and the Orbiter Experiment program (OEX).

In 1980, the entry technology research will provide the aerothermodynamic data required for the design, development, and verification of planetary entry vehicles. and for computational fluid dynamic codes to predict space vehicle flow fields and performance. Work is proceeding to apply laser physics and laser techniques to the development of flow diagnostic tools to remotely probe gas dynamic flows in order to define and verify turbulence models. Research efforts in the materials area will provide thermal protection systems concepts and materials for heat shields to protect earth and planetary entry vehicles (probes); develop computational chemistry codes to calculate basic properties of matter; and expand the understanding of surface-environment inter-actions (corrosion). Research is also being conducted in the advanced electronics and materials area to determine atomic structure and properties of absorbed surface layers and to advance the state of the art of computing wave functions for molecules and atomic clusters.

In 1980, the Shuttle project will be supported with wind tunnel tests of models to study a variety of aerodynamic and thermodynamic problems. The Galileo project will be supported with heat shield design and performance data, heat shield shape change effects on aerodynamics, and subsonic probe stability. In the area of orbiting astronomical instruments, work will continue to develop infrared detectors, to define systems for precision pointing and control of telescopes and to advance the technology required to cool the detectors to below 10 degrees Kelvin for support of the Infrared Astronomy Satellite (IRAS) project. Ames Research Center is supporting two space shuttle orbiter experiments. The first is to design, develop and conduct an OEX experiment for Infrared Imaging of Shuttle (IRIS) to obtain measurements of surface temperatures of the lower and side surfaces of the orbiter by remote imagery from the C-141 Kuiper Airborne Observatory. The second is to conduct OEX thermal protection experiments to study advanced materials and to evaluate possible cost and weight reductions for the thermal protection system for Shuttle and Advanced Space Transportation Systems.

CENTER MANAGEMENT AND OPERATIONS SUPPORT — 416 Permanent Positions (Civil Service)

Center Management and Operations Support is defined as that support or services being provided to all Ames Research Center organizations which cannot be directly identified to a benefiting program or project. The civil service personnel involved are:

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Director and Staff

The Center director, deputy director and the immediate staff, e.g., legal, patent counsel, equal opportunity, planning and analysis, public affairs, energy management and safety.

Management Support

Includes a wide range of activity categorized as management support for programs and functional organizations for the entire Center. Specific functions include resource and budget management, program control, contracting and procurement, personnel management, property management, financial management, resource control and management information systems and analysis.

Operations Support

This is a broad spectrum of activity that is required to maintain and operate facilities, buildings, and equipment, and to provide the normal housekeeping services and logistics support for the personnel who manage and conduct the affairs of the Center. Specific activities are:

Maintenance and operation of all buildings and facilities
Administrative data processing and computer support
Centerwide security and protection
Fire protection
Custodial services
Logistics support including transportation, supplies, etc.
Medical care of employees

PERSONNEL AND RELATED COSTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
I. PERSONNEL AND RELATED COSTS	48,214	49,377	52,584	53,514

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Basis of Fund Requirements				
A. Compensation and Benefits				
1. Compensation				
a. Permanent positions	42,515	43,291	46,306	47,175
b. Nonpermanent	583	748	858	800
c. Reimbursable detailees	83	313	132	168
d. Overtime and other compensation	422	427	436	436
Subtotal, Compensation	43,603	44,779	47,732	48,579
2. Benefits	4,241	4,370	4,557	4,655
Subtotal, Compensation and Benefits	47,844	49,149	52,289	53,234
B. Supporting Costs				
1. Transfer of personnel	157	33	100	85
2. Personnel training	213	195	195	195
Subtotal, Support Costs	370	228	295	280
Total, Personnel and Related Costs	48,214	49,377	52,584	53,514
A. Compensation and Benefits	47,844	49,149	52,289	53,234
1. Compensation	43,603	44,779	47,732	48,579
a. Permanent Positions	42,515	43,291	46,306	47,175

The funds will support 1,653 permanent positions in 1980, a reduction of 13 positions from the 1979 level. The increase from the 1979 budget estimate to the current estimate is due to the October 1978 pay raise, partially offset by savings from the reduction of 11 permanent positions.

Basis of Cost for Permanent Positions

In 1980 the cost of permanent positions will be $47,175,000. The increase from 1979 results from the following:

Cost of permanent positions in 1979		46,306
Cost increase in 1980		+1,262
Within grade advances and career development:		
Full year effect of 1979 actions	+394	
Partial year effect of 1980 actions	+392	
Full year effect of 1979 pay raise	+134	
Two extra paid days in 1980	+342	
Cost decreases in 1980		-393
Turnover savings and abolished positions:		
Full year effect of 1979 actions	-214	
Partial year effect of 1980 actions	-179	
Cost of permanent positions in 1980		47,175

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
b. Nonpermanent positions				
1. Cost	583	748	858	800
2. Workyears	74	85	98	93

The increase from the 1979 budget estimate to the 1979 current estimate is due to the inclusion of a non-baccalaureate cooperative training program and a part-time employment program. The decrease from the 1979 estimate to the 1980 estimate is due to the absorption of the part-time permanent program into the permanent position ceiling. The 1980 plan includes 93 workyears which will support the following programs:

Distribution of Nonpermanent Workyears

Program	Workyears
Cooperative training programs	27
Summer programs	15
Youth opportunity programs	28
Other temporary employment	23
Total	93

The increase from the 1979 budget estimate is due to the inclusion of a non-baccalaureate cooperative training program and a part-time employment program.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
c. Reimbursable detailees	83	313	132	168

The military personnel detailed to the Ames Research Center on a reimbursable basis are individuals experienced in aeronautics, rotorcraft technology and related fields. The decrease from the 1979 budget estimate to the 1979 current estimate reflects the phase-out of five GSA detailees who provided computer programming support. The increase in 1980 is due to full-year payment of four detailees phased in during 1979 for the rotorcraft program.

d. Overtime and other compensation	422	427	436	436

Overtime and night differential are used primarily for off-shift operation of major wind tunnel facilities such as the Unitary Plan Wind Tunnel System, the 40- by 80-Foot Subsonic Wind Tunnel, and the 6- by 6-Foot Supersonic Wind Tunnel. The slight increase from the 1979 budget estimate is due to the operation of new experimental aircraft and modification of the 40- by 80-Foot Subsonic Wind Tunnel.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
2. Benefits	4,241	4,370	4,557	4,655
Following are the amounts of contribution by category:				
Category of Costs				
Civil Service Retirement Fund	2,990	3,112	3,231	3,291
Employee life insurance	172	187	183	190
Employee health insurance	821	821	884	915
Workmen's compensation	205	205	216	216
FICA	18	16	18	18
Incentive Awards	35	29	25	25
Total	4,241	4,370	4,557	4,655

The increase from the 1979 budget estimate to the 1979 current estimate is due to the October 1978 pay raise and higher health benefit contributions,which are partially offset by the savings from the reduction of 11 permanent positions. The increase in 1980 over 1979 is related to the increase in personnel compensation and is partially offset by the savings due to the manpower reductions.

B. Supporting Costs	370	228	295	280
1. Transfer of personnel	157	33	100	85

The increase from the 1979 budget estimate to the 1979 current estimate is due to personnel transferring to Ames with the rotorcraft project.

2. Personnel training	213	195	195	195

The 1980 estimate for training costs will be at the 1979 level.

TRAVEL

II. TRAVEL	1,101	1,230	1,218	1,313

Basis of Fund Requirements

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
A. Program Travel	796	865	858	927
B. Scientific and Technical Meeting Travel	111	135	135	145
C. Management and Operations Travel	194	230	225	241
Total, Travel	1,101	1,230	1,218	1,313
A. Program Travel	796	865	858	927

Program travel is required for the accomplishment of the Center's mission and is the largest part of the Ames travel budget, accounting for 71 percent of travel costs for 1980. Travel for program purposes is required for the continuing efforts in space research, aircraft technology, flight simulation, fluid mechanics, airborne science and applications, and space life sciences.

The increase in 1980 over the 1979 current estimate is required for support of the Infrared Astronomy Satellite (which will require travel to Europe), Galileo, Western Regional Applications Program (covering 14 states including Hawaii and Alaska), increased C-141 flights, acquisition of additional rotorcraft from Langley Research Center, the participation in the Kosmos launch, and the monitoring of various contractors' performance in the construction of the 80- by 120-Foot Wind Tunnel test section.

B. Scientific and Technical Meeting Travel	111	135	135	145

Scientific and technical meeting travel permits employees to participate in meetings and technical seminars with other representatives of the aerospace community. This participation allows them to benefit from exposure to technological advances outside ARC, as well as to present both accomplishments and problems to their associates. Many of the meetings are made up of working panels convened to solve certain problems for the benefit of the Government. The level of travel in 1980 is expected to increase to provide for the presentation of additional aeronautical papers to the scientific community.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
C. Management and Operations Travel	194	230	225	241

Management and operations travel provides for the direction and coordination of general management matters. It includes travel in such areas as personnel, financial management and procurement activities; and travel of the Center's top management to NASA Headquarters, other NASA Centers, and contractor plants; and local transportation. The increase in 1980 is due to inclusion of the Air Charter Service to transport research pilots from Ames to the U.S. Naval Air Station, Crows Landing, and to test the Micro-Wave Landing System.

FACILITIES SERVICES

Ames Research Center (ARC) is located on 421 acres of ground in a complex of facilities made up of laboratory and office type buildings as well as research wind tunnels.

This complex encompasses 2,310,527 gross square feet of building space including 10 major buildings. Also included are 11 major technical facilities. This physical plant supports an average daily population of 2,500 to 2,900 personnel. Many of the facilities are utilized on schedules involving more than one shift and frequently during off-peak hours.

Basis of Fund Requirements

III. FACILITIES SERVICES	5,093	5,309	6,675	7,439
A. Maintenance and Related Services				
1. Facilities	190	143	127	129
2. Equipment	85	65	62	63
Subtotal	275	208	189	192
B. Custodial Services	1,327	1,350	1,561	1,640
C. Utilities Services	3,491	3,751	4,925	5,607
Total, Facilities Services	5,093	5,309	6,675	7,439

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
A. Maintenance and Related Services	275	208	189	192
1. Facilities	190	143	127	129
2. Equipment	85	65	62	63

The level of maintenance in 1978 reflects one-time roof repairs to three facilities. The increase reflected in the 1980 budget estimate allows a modest growth in unit costs at the same level of services.

B. Custodial Services	1,327	1,350	1,561	1,640

The increase in the 1979 current estimate provides for a three workyear increase and additional supplies and materials for an additional 122,000 square feet of laboratory and warehouse facilities. The 1980 budget reflects only unit cost growth over the 1979 current estimate. Included are:

1. Janitorial services (35 workyears of effort) 684

Janitorial and building cleaning services are associated with approximately 1.6 million square feet of various types of space located in 75 buildings. Services are also provided for 50 trailers being utilized to provide temporary office and shop space.

2. Fire protection services 360

Fire protection services are provided by the U.S. Naval Air Station, Moffett Field, CA. The 1980 estimate is based on the most recent actual cost experience.

3. Security services (27 workyears of effort) 495

Included are security services for buildings and property, including aircraft and computer facilities. Included also is the provision of "round-the-clock" staffing of the emergency duty office which monitors fire, security, and safety alarms and coordinates fire, security, health, and safety areas in emergency situations.

4. Other services 101

Pest control services, on an as needed basis, are funded in this activity. Also included are refuse collection, laundry and custodial supplies.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
C. Utilities Services	3,491	3,751	4,925	5,607

The major utility service is electricity with lesser requirements for natural gas, fuel, oil, water and sewage services.

1. Electricity (215,000 MW/Hrs.)	4,580
2. Natural gas (214,000 K Cu. Ft.)	797
3. Fuel oil (235,000 gals.)	113
4. Water and sewage	117

Electricity is provided by the U.S. Bureau of Reclamation (USBR) and the Pacific Gas and Electric Company (PGECO), natural gas is provided by PGECO, water by the U.S. Naval Air Station, Moffett Field, and sewage services by the City of Mountain View.

Approximately 80% of electric power costs is consumed in the operation of high power demand research facilities such as the Unitary Plan Wind Tunnel System, the 40- by 80-foot Wind Tunnel, the 3.5-foot Hypersonic Tunnel, the 14-foot Transonic Wind Tunnel and in the operation of simulators and smaller wind tunnels, and other research facilities. Approximately 55% of natural gas is used in research facilities; the other part is used for heating and ventilation of institutional buildings. The funding level for 1980 will provide approximately 215 million KWH compared to 204 million KWH used in 1978 and the 242 million KWH planned for 1979.

The increase in the 1979 current estimate is a combination of recent industry requests and a seven-shift operation for increased programmatic requirements. Increases from the 1979 current estimate to the 1980 budget estimate allow only for rate increases by the U.S. Bureau of Reclamation and the Pacific Gas and Electric Company

TECHNICAL SERVICES

IV. TECHNICAL SERVICES	621	607	686	909

Basis of Fund Requirements

A. Automatic Data Processing				
1. Operations	296	301	363	478
Subtotal	296	301	363	478

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
B. Scientific and Technical Information				
1. Education and Information	244	261	241	257
Subtotal	244	261	241	257
C. Shop Support and Services	81	45	82	174
Total, Technical Services	621	607	686	909

A. Automatic Data Processing

Obligations for administrative ADP operations and programming reflect ADP central facility operating costs which are incurred by administrative organizations. The ADP computer operations and programming are charged to institutional organizations through the Center's charge-back systems. The charges include the institutional organizations' porportionate share of support service contracts. The increase in the 1979 current estimate provides for 2 additional workyears to more accurately account for support required for administrative computing. The 1980 increase will provide for the full year effect of 1979 cost increases related to the central ADP facility.

1. Operation (14 workyears of effort)	296	301	363	478
B. Scientific and Technical Information	244	261	241	257

Included in this category is a support service contract at a level of 11 workyears to perform public information services (e.g., tour guide), media development (e.g., public exhibits, etc.) and educational programs. The increase in 1980 reflects the full year effect of previously negotiated contractor wage rates at the same level of effort provided in 1979.

1. Education and information	244	261	241	257
C. Shop Support and Services	81	45	82	174

This category includes administrative shop, photo and graphics services. The increase in the 1980 estimates are due to requirements of new exhibits (models and graphics) related to the Pioneer-Venus program.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
V. MANAGEMENT AND OPERATIONS	2,701	2,689	2,598	2,664
Basis of Fund Requirements				
A. Administrative Communications	739	895	824	835
B. Printing and Reproduction	106	93	101	102
C. Transportation	47	189	37	38
D. Installation Common Services	1,809	1,512	1,636	1,689
Total, Management and Operations	2,701	2,689	2,598	2,664
A. Administrative Communications	739	895	824	835

Communication services are provided by General Services Administration (GSA) for the Federal Communications Service (FTS) and the Pacific Telephone and Telegraph Company for local service. Other communications consist of teletype equipment and services provided by Western Union. The increase in 1980 is due to the full year effect of 1979 rate increases.

1. Local telephone services..... 420

The major part of this covers 1,470 Centrex lines and 2,258 telephone instruments which serves about 3,400 individuals on-site at ARC, including on-site contractors and tenants from other Government agencies.

2. Long distance telephone service..... 395

This item is primarily (98%) FTS services; the balance (2%) includes commercial long distance, message unit charges and leased line services charges.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		

3. Non-telephone communications..... 20

Includes Western Union telegraphic services and leased equipment.

B. Printing and Reproduction..... 106 93 101 102

The estimates for administrative printing includes the Printing and Reproduction Facility operating costs incurred by administrative organizations and includes supplies, materials, equipment acquisition and outside procurements. The 1980 estimate is essentially level from 1979.

C. Transportation..... 47 189 37 38

The estimates include freight costs, government bills of ladings, air freights and other general shipments. The 1979 current estimate reflects a recategorization of certain travel costs of GSA rental vehicles into the Management and Operations travel function. The 1980 estimate is essentially level.

D. Installation Common Services..... 1,809 1,512 1,636 1,689

These services include the Center Management and Staff function, the medical services operation, and the installation support services activities. The increase in 1980 results from the full year effect of 1979 rate increases.

1. Center management and staff..... 305

Includes the general management of the Center as an installation and includes such activities as the directorate offices, general and patent legal services, personnel, procurement, and financial management services. Significant cost items include the various Equal Employment Opportunity (EEO) programs for minorities and females, the Intergovernmental Personnel Act (IPA) programs, and studies and development of management systems.

2. Medical services..... 260

Medical services include the staffing of the Health Unit, laboratory service fees, clinic supplies, and maintenance of clinic equipment.

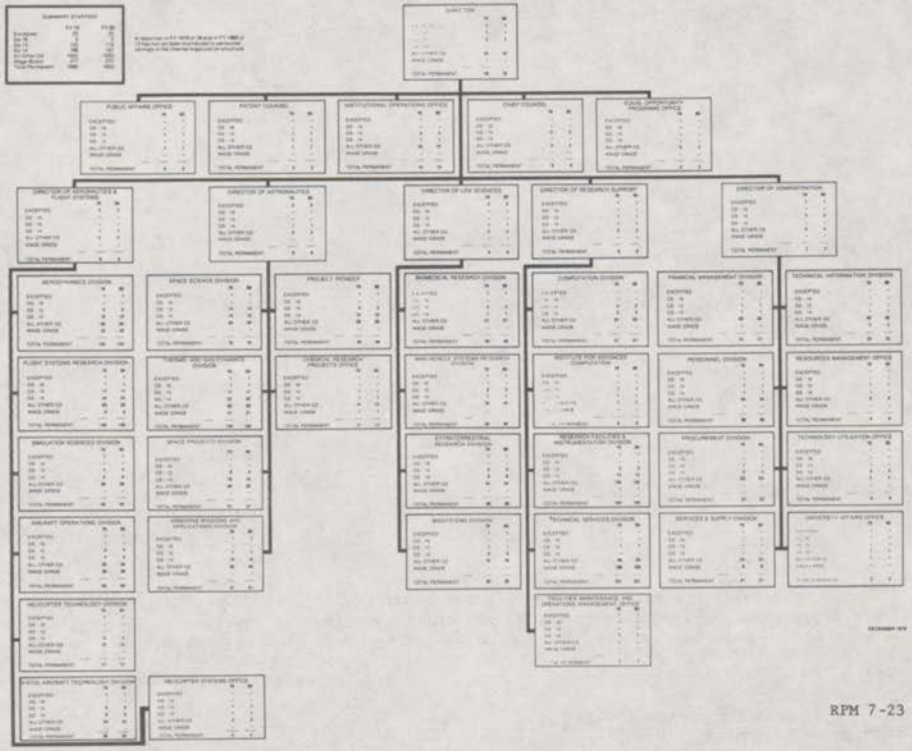
	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
3. Installation support services (31 workyears of effort).....				1,124

Installation support services consist predominantly of the support service contract for supply management, mail, and pickup and delivery services. The balance of the functional costs consist of administrative equipment acquisition, office supplies and materials, maintenance and repair and lease of office equipment, and postage.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

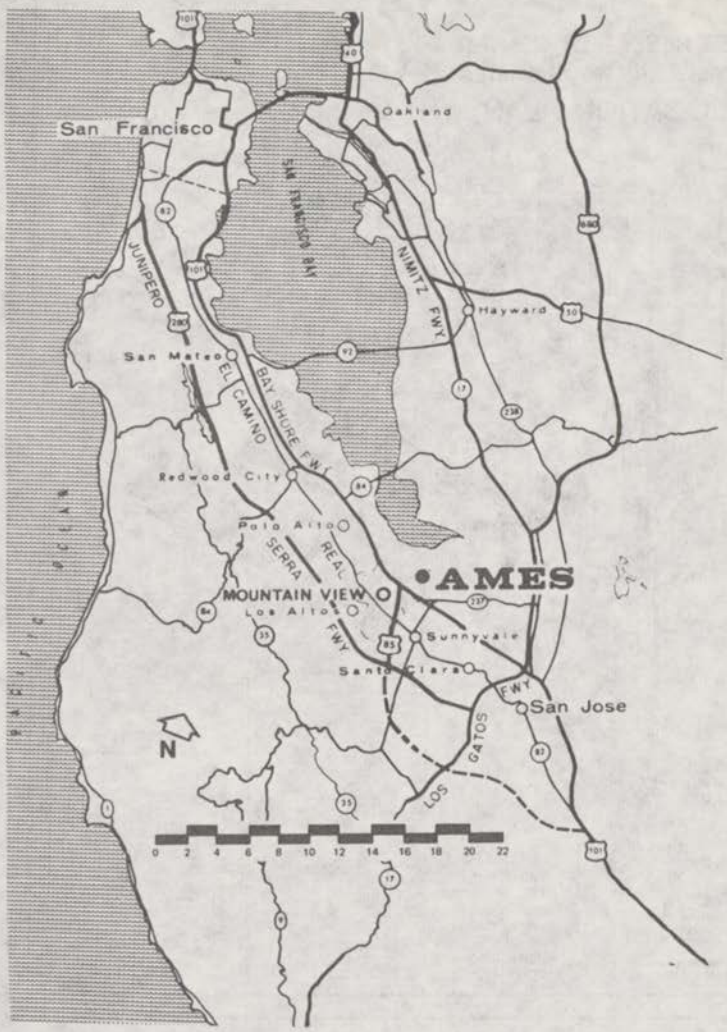
ORGANIZATION AND STAFFING CHART

AMES RESEARCH CENTER

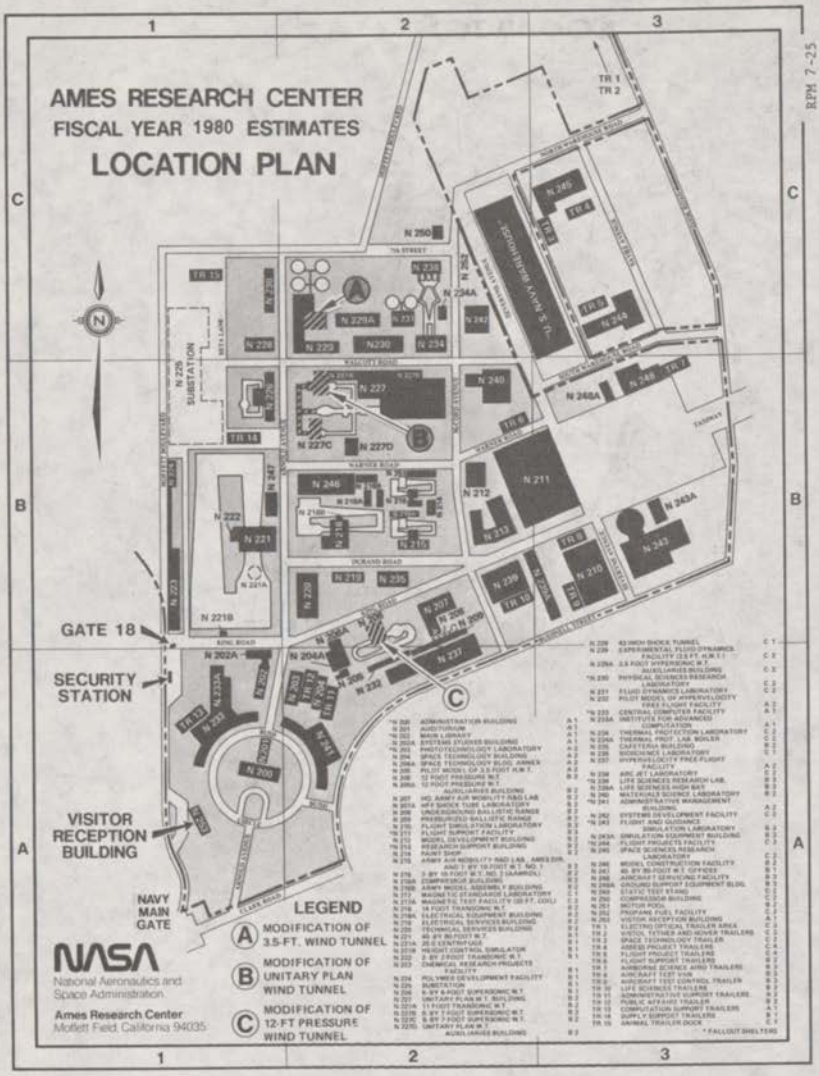


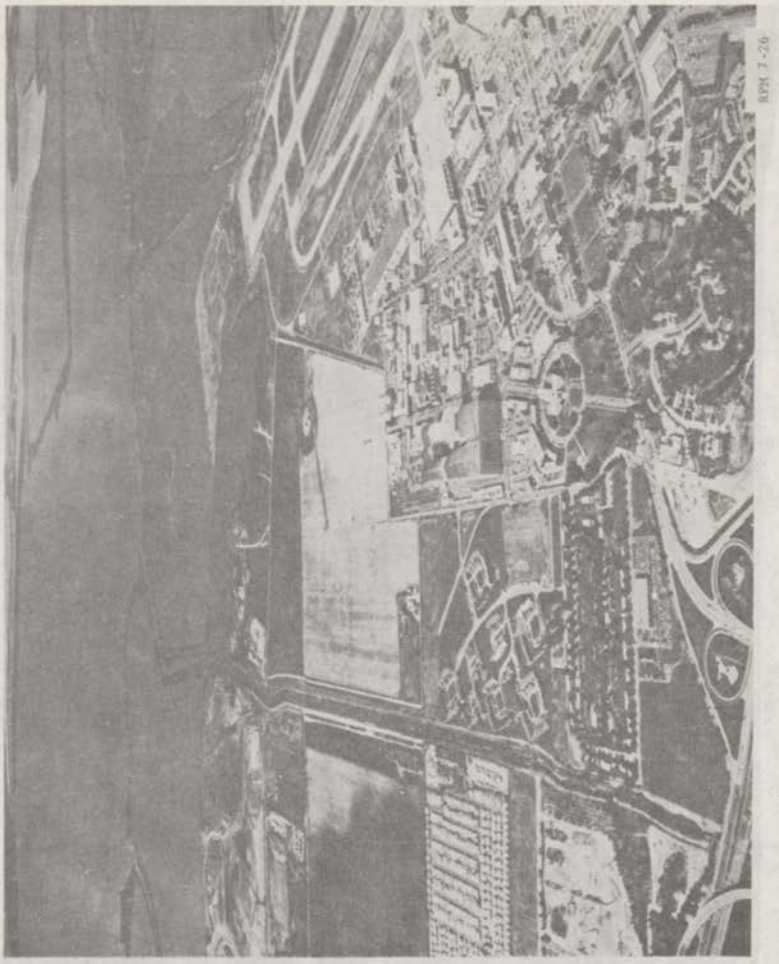
RPM 7-23

LOCATION MAP



RPM 7-24


AMES RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES
LOCATION PLAN
RPM 7-25
GATE 18
SECURITY STATION
VISITOR RECEPTION BUILDING
NAVY MAIN GATE
LEGEND
A MODIFICATION OF 3.5-FT. WIND TUNNEL
B MODIFICATION OF UNITARY PLAN WIND TUNNEL
C MODIFICATION OF 12-FT PRESSURE WIND TUNNEL
NASA
National Aeronautics and Space Administration
Ames Research Center
Moffett Field, California 94035



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RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1980 ESTIMATES

HUGH L. DRYDEN FLIGHT RESEARCH CENTER

DESCRIPTION

The Hugh L. Dryden Flight Research Center (DFRC), Edwards, California, is 65 air miles northeast of Los Angeles. The Center is located at the north end of Edwards Air Force Base on 521 acres of land under a permit from the Air Force. The Air Force Base encompasses 300,722 acres. The Center is adjacent to Rogers Dry Lake, a 55-square mile area with a complex of runways varying in length from five to eleven miles.

The physical plant consists of an office-laboratory building with adjoining shops, a flight maintenance hangar, a flight loads research facility, and an integrated support facility. Special Shuttle support facilities include the Orbiter hangar and the Orbiter mating-demating facility. Auxiliary buildings include warehouses, an auxiliary power system building, an aircraft maintenance dock, and hangar. The aerodynamic test range is operated with sites at Edwards, California, and Ely, Nevada. The total capital investment of the Dryden Flight Research Center, including fixed assets in progress and contractor held facilities at various locations, as of September 30, 1978, was $80,647,000.

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CENTER ROLES AND MISSIONS

The primary mission of the Dryden Flight Research Center, established in 1947, is to conduct aeronautical flight research in the areas of aerodynamics, structures, control systems, propulsion systems, disciplinary integration effects, safety, operations, and human-vehicle interactions in support of both military and civil national needs. This includes planning, conducting, analyzing, and reporting of flight research for the purposes of verification of predicted characteristics and the identification of unanticipated problems in actual flight. The principal and supporting roles of the Center are:

PRINCIPAL

Aeronautical Flight Research - conducting aeronautical flight research in the areas of aerodynamics, structures, control systems, propulsion systems, disciplinary integration effects, safety, operations, and human-vehicle interactions, which involves the planning and preparation of flight test programs, the development

of flight test instrumentation, flight testing, and data analysis. DFRC also provides host Center functions for NASA flight activities which are managed by other Centers but which require testing at the Edwards AFB complex. This function includes all institutional support and coordination as well as supervision of flight operations.

Remotely Piloted Vehicle Research - development of remotely piloted research aircraft, and management and operation of flight experiments.

SUPPORTING

Shuttle Orbiter - provide landing and recovery capability during Orbital Flight Tests (OFT) and contingency recovery capability after OFT.

Advanced Space Vehicle Configurations Technology - analysis and study of the effect of operational considerations on the design and test program of piloted research vehicles.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
I. Personnel and Related Costs	13,777	13,798	14,396	14,270
II. Travel	306	388	369	415
III. Facilities Services	2,457	3,628	2,448	2,661
IV. Technical Services	226	348	409	458
V. Management and Operations	1,481	1,319	1,935	1,987
Total, fund requirements	18,247	19,481	19,557	19,791

Distribution of Permanent Positions by Program

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Direct Positions				
Space Transportation Systems	13	37	34	19
Space shuttle	13	37	34	19
Space Science	1	1	1	1
Life sciences	1	1	1	1
Space and Terrestrial Applications	1	1	1	1
Technology utilization	1	1	1	1
Aeronautics and Space Technology	348	324	319	319
Aeronautical research and technology	348	324	319	319
Space Tracking and Data Systems	30	30	30	30
Tracking and Data Acquisition	30	30	30	30
Subtotal, direct positions	393	393	385	370
Center Management and Operations Support Positions	97	97	95	91
Total, permanent positions	490	490	480	461

PROGRAM DESCRIPTION

SPACE SHUTTLE — 19 Permanent Positions (Civil Service)

In 1980, 19 civil service personnel will be utilized at Dryden Flight Research Center (DFRC) to support the Shuttle Orbital Flight Test (OFT) activities. Current planning is for Edwards Air Force Base to be the primary landing site for the first four missions and the secondary landing site for missions five and six. After landing, the shuttle orbiter will be returned to Kennedy Space Center by shuttle carrier aircraft. Payloads will be removed prior to shuttle ferry. DFRC will provide operational support and institutional support for the Space Shuttle landing activities at Edwards. In addition, DFRC will serve as an interface to the Air Force Flight Test Center, provide aircraft to test the Microwave Scanning Beam Landing System, and provide provide Orbiter Convoy operations support. In 1979, DFRC will perform the Orbiter elevon seals test.

LIFE SCIENCES — 1 Permanent Position (Civil Service)

In 1980, one civil servant is required to develop and evaluate cost effective, reliable human/machine control systems for use in remote manipulation such as manual landing of Shuttle type vehicles. Flight studies of remotely piloted high-performance vehicles will be performed to determine information requirements and procedures necessary for descent, approach, flare, touchdown, and roll out without direct external vision. Television sensors and displays with inside-out references will be evaluated to define optimum human/machine design characteristics.

TECHNOLOGY UTILIZATION — 1 Permanent Position (Civil Service)

In 1980, one civil servant is required to continue studies of various means to improve the aerodynamic efficiency of ground vehicles. Various add-on devices, which potentially could be manufactured by small businesses, will be evaluated.

AERONAUTICAL RESEARCH AND TECHNOLOGY — 319 Permanent Positions (Civil Service)

In 1980, three hundred and nineteen civil service personnel are required to accomplish aeronautical flight research activities at the DFRC. The aeronautical program includes research and technology; systems technology; experimental programs involving structures, fluid and flight dynamics, avionics, aircraft operations and safety, aeronautical human-vehicle interaction, aerodynamic vehicles, advanced civil and military aircraft, and highly maneuverable aircraft; and experimental aircraft research in Short Takeoff and Landing (STOL), supersonic cruise, and tilt rotor vehicles.

In 1980, the objectives of the activities under the research and technology programs are to provide continuing research and development efforts in all disciplinary areas so that improved understanding can be applied to problems associated with aircraft in all flight regimes.

Under the systems technology program, in 1980, flight research of the digital fly-by-wire system, to provide technology for implementation in future aircraft, will be continued; full-scale flight test evaluations of various wake vortex alleviation devices will continue; the KC-135 aircraft will be used to test the winglet concept as a fuel savings means for current and future military and commercial transport aircraft; acoustic flight tests of an advanced high tip-speed propeller will be conducted in support of the advanced turboprop program; and flight research will continue to demonstrate the advantages of integrated airframe/propulsion control systems.

Within the experimental aircraft research programs, the Highly Maneuverable Aircraft Technology aircraft will be flight tested; the high speed flight testing support of a tilt rotor research aircraft is being coordinated to demonstrate the tilt rotor concept for civil and military applications; and flight test support will be provided for the evaluation of STOL research aircraft.

TRACKING AND DATA ACQUISITION — 30 Permanent Positions (Civil Service)

In 1980, thirty civil service personnel are required to maintain and operate the NASA Aerodynamic Test Range (ATR), which provides direct operational support for a wide variety of aerodynamic and aerospace programs conducted by DFRC, other NASA Centers, military services, and supporting contractors. During mission support operations, the various functional elements such as radar, tracking and data processing, communications, video, telemetry acquisition, and telemetry data processing all function in a coordinated manner to provide real time control and monitoring capabilities. Data links between the various Edwards facilities and the remote Ely Tracking Station provide continuous control and monitoring capabilities over the entire ATR.

CENTER MANAGEMENT AND OPERATIONS SUPPORT — 91 Permanent Positions (Civil Service)

Center Management and Operations Support is defined as that support or services being provided to all Dryden Flight Research Center organizations which cannot be directly identified to a benefitting program or project. The civil service personnel involved are:

Director and Staff - The Center Director, Deputy Director and immediate staff, and staff organizations, e.g., Legal, Patent Counsel, Equal Opportunity, and Public Affairs.

Management Support - Includes a wide range of activity categorized as management support for programs and functional organizations for the entire Center. Specific functions include resource and budget management, program control, contracting and procurement, personnel management, institutional support, financial management, and management information systems and analysis.

Operations Support - This is a broad spectrum of activity that is required to maintain and operate facilities, buildings, and equipment; and to provide the normal housekeeping services and logistics support for the personnel who manage and conduct the affairs of the Center. Specific activities are:

Maintenance and operation of all buildings and facilities
Data processing and computer support
Reliability and quality assurance
Center-wide security and protection
Fire protection
Custodial services
Logistics support including transportation, supplies, etc.
Medical care of employees
Photographic and graphic support

PERSONNEL AND RELATED COSTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
I. PERSONNEL AND RELATED COSTS	13,777	13,798	14,396	14,270
Basis of Fund Requirements				
A. Compensation and Benefits				
1. Compensation				
a. Permanent positions	11,825	11,760	12,293	12,200
b. Nonpermanent	426	352	403	382
c. Reimbursable detailees	32	101	99	106
d. Overtime and other compensation	148	247	204	184
Subtotal, Compensation	12,431	12,460	12,999	12,872

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
2. Benefits	1,227	1,194	1,253	1,248
Subtotal, Compensation and Benefits	13,658	13,654	14,252	14,120
B. Supporting Costs				
1. Transfer of personnel	30	58	58	58
2. Personnel training	89	86	86	92
Subtotal, Supporting Costs	119	144	144	150
Total, Personnel and Related Costs	13,777	13,798	14,396	14,270
A. Compensation and Benefits	13,658	13,654	14,252	14,120
1. Compensation	12,431	12,460	12,999	12,872
a. Permanent positions	11,825	11,760	12,293	12,200

The 1980 estimate supports a permanent personnel complement of 461 positions, a reduction of 29 positions from the 1979 level. The current estimate for 1979 is increased from the 1979 budget estimate as a result of the October 1978 pay increase partially offset by savings from the reduction of 10 permanent positions.

Basis of Cost for Permanent Positions

In 1980, the cost of permanent positions will be $12,200,000, a reduction of $93,000 from the 1979 level. The estimates are derived from the following calculations:

Cost of permanent positions in 1979	12,293
Cost of increases in 1980	+390

Within grade advances and career development		
Full year effect of 1979 actions	+136	
Partial year effect of 1980 actions	+144	
Full year effect of October, 1978 pay increase	+ 12	
Two extra paid days in 1980	+ 98	
Cost decreases in 1980		-483
Turnover savings and abolished positions		
Full year effect of 1979 actions	- 95	
Partial year effect of 1980 actions	-388	
Cost of Permanent positions in 1980		12,200

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Other Compensation Costs				
b. Nonpermanent Positions				
1. Cost	426	352	403	382
2. Workyears	46	43	47	44

The 1979 current estimate increases from the 1979 budget estimate due to the addition of a part-time employment program. The 1980 plan reflects a decrease as a result of absorption of the part-time program in the permanent position ceiling. This effort will support the following programs as shown:

Distribution of Nonpermanent Workyears by Program

Program	Workyears
Cooperative training	27
Opportunity programs	12
Summer employment	2
Other temporary employment	3
Total	44

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
c. Reimbursable detailees	32	101	99	106

The services of a small group of military officers are used in the Center's programs where such assignments are of mutual benefit to NASA and the respective service. Under the existing agreements, the parent organization is reimbursed for salaries and related costs.

d. Overtime and other compensation	148	247	204	184

Overtime is restricted to emergency repairs and abnormal temporary workload. A substantial portion is used to prepare for test flights. The 1979 current estimate decreases from the 1979 budget estimate due to the slippage of OFT flights into 1980 and a reestimate of shuttle support requirements.

2. Benefits	1,227	1,194	1,253	1,248

The current estimate for 1979 is higher than the 1979 budget estimate due to the October 1978 pay raise which is partially offset by the savings from the reduction of 10 permanent positions. The 1980 estimate reflects the full year cost of the pay raise and higher health benefits which are partially offset by savings due to the manpower reductions.

Category of Cost

Civil Service Retirement Fund	854	828	886	869
Employee life insurance	50	53	42	42
Employee health insurance	254	250	260	270
Workmen's compensation	31	31	31	33
FICA	14	7	7	7
Incentive Awards	21	25	27	27
Severance pay	3	---	---	---
Total	1,227	1,194	1,253	1,248

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
B. Supporting Costs	119	144	144	150
1. Transfer of personnel	30	58	58	58

The costs associated with the transfer of personnel include movement of household goods, subsistance and temporary expenses, real estate costs and miscellaneous moving expenses related to change of duty station.

2. Personnel training	89	86	86	92

Training funds provide for the maintenance and expansion of skills which are essential in carrying out the agency's many complex technical programs. The cost reflects tuition and related fees at a number of government and nongovernment institutions. The 1980 amount allows for announced increases in tuition costs.

TRAVEL

II. TRAVEL	306	388	369	415
Basis of Fund Requirements				
A. Program Travel	190	240	246	280
B. Scientific and Technical Meeting Travel	25	31	28	31
C. Management and Operations Travel	91	117	95	104
Total, Travel	306	388	369	415
A. Program Travel	190	240	246	280

Program travel is directly related to the accomplishment of the Center's mission, and accounts for 67 percent of the 1980 travel estimate. The increase in 1980 is a result of joint programs, between DFRC and other Centers, which require additional travel funds for necessary planning, coordination and management. These joint programs include Advance Turbo Prop, Lamanar Flow Control, F-15 Profit and the Highly Maneuverable Aircraft Technology Augmentation.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
B. Scientific and Technical Meeting Travel.....	25	31	28	31

Scientific and technical meeting travel permits employees to participate in meetings and seminars with other representatives of the aerospace community. This participation allows them to benefit from exposure to technical advances outside DFRC, as well as to present accomplishments and problems to their associates. Many of the meetings consist of working panels convened to solve specific governmental problems. It is estimated that travel requirements in 1980 will be at the 1979 level.

C. Management and Operations Travel.....	91	117	95	104

Management and operations travel is used for the direction and coordination of general management matters. It includes travel in such areas as personnel, financial management, and procurement activities; travel of the Center's top management to NASA Headquarters and other NASA Centers; administrative training travel; and local transportation. Slight increase in 1980 results from increased costs related to air travel.

FACILITIES SERVICES

The Dryden Flight Research Center (DFRC) is located on 521 acres and occupies a complex of facilities consisting of laboratory and office-type buildings as well as flight test facilities

This complex encompasses 446,347 gross square feet of building space including two major buildings. Also included are seven major technical facilities. This physical plant houses an average daily on-Center population of 1,200 to 1,500 personnel of all types. Many of the test facilities are utilized on schedules involving more than one shift.

III. FACILITIES SERVICES.....	2,457	3,628	2,448	2,661
Basis of Fund Requirements				
A. Rental of Real Property.....	44	77	50	65

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
B. Maintenance and Related Services				
1. Facilities	1,026	1,660	965	1,048
2. Equipment	113	93	77	80
Subtotal	1,139	1,753	1,042	1,128
C. Custodial Services	1,027	1,406	962	1,015
D. Utility Services	247	392	394	453
Total, Facilities Services	2,457	3,628	2,448	2,661
A. Rental of Real Property	44	77	50	65

This item provides for the rental of trailers to provide office, shop, laboratory, and storage space in support of the Space Shuttle Orbital Flight Test (OFT) Program. The 1979 current estimate is reduced from the 1979 budget estimate due to a reduction in the number of OFT flights in 1979. The increase in 1980 is to support the current OFT flight schedule.

B. Maintenance and Related Services

1. Facilities	1,026	1,660	965	1,048

This activity involves DFRC and Air Force facilities used by Shuttle, and remotely-sited tracking and communication facilities. The decrease of the 1979 current estimate from the 1979 budget estimate is derived from the transfer of Supply Management to the Management and Operations function. The increase in 1980 is to support the current OFT flight schedule.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
a. Maintenance and repair services (31 workyears of effort)				814
Maintenance and repair to include routine maintenance of applicable facilities				
b. Engineering services (four workyears of effort)				109
c. Supplies and materials				44
d. Other services				81
2. Equipment	113	93	77	80

This activity involves three workyears of effort for the maintenance of facility-type equipment by our support service contractor.

C. Custodial Services	1,027	1,406	962	1,015

This activity involves a total of 43 workyears of effort to provide for security, janitorial, and refuse handling. The reduction in funding required in the 1979 current estimate is based on a reduced level of effort to support the OFT Program. The increase in 1980 is to support the current OFT flight schedule.

1. Janitorial services (19 workyears of effort) 493

This activity includes:

a. Janitorial services
b. Refuse and pest control

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
2. Security guard services (24 workyears of effort)				522

This activity includes:

a. Security of all on-site Government facilities and equipment
b. Mail and messenger service
c. Badging of all on-site personnel and visitors

D. Utilities	247	392	394	453

Utility services are purchased through USAF contracts with regional utility companies. Costs are based on Air Force projected rates. The major amount is for electricity with lesser amounts for natural gas, fuel oil, water and sewage services. A summary of the proposed DFRC utilities budget for 1980 is as follows:

1. Electricity (14,000 mWh)	314
2. Natural gas (23,000 K cu. ft.)	96
3. Fuel oil (47,000 gals.)	27
4. Water and sewage	14
5. Other	2
Total	453

TECHNICAL SERVICES

IV. TECHNICAL SERVICES	226	348	409	458

Basis of Fund Requirements

A. Automatic Data Processing				
1. Operations	86	218	218	261
Subtotal	86	218	218	261

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
B. Scientific and Technical Information				
1. Library	1	14	14	15
2. Education and information	34	49	60	66
Subtotal	35	63	74	81
C. Shop Support and Services	105	67	117	116
Total, Technical Services	226	348	409	458
A. Automatic Data Processing	86	218	218	261

Covers the support required for administrative keypunch and programming operations at the Center to satisfy payroll, personnel, accounting, and management information systems requirements of NASA and DFRC management. The 1979 and 1980 estimates include funds for the development of a management information system and maintenance of the existing systems.

B. Scientific and Technical Information	35	63	74	81

Includes the purchase of books, supplies, and materials for, and operation of the Dryden Flight Research Center Library. It also provides for public information services.

1. Library	1	14	14	15

Provides for the purchase of books, supplies, and materials for, and the operation of the Dryden Flight Research Center Library.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
2. Education and Information	34	49	60	66

Provides for the gathering and dissemination of information about the Center's programs to the mass communications media, the general public, and to the educational community at the elementary and secondary school levels. Assistance to the mass communications media includes the gathering and exposition of newsworthy material in support of media requests, and takes such forms as press kits, news releases, television and radio information tapes and clips, and feature material. The increase in 1980 reflects the full year effort of rate increases in 1979 with services at the current level.

C. Shop Support and Services	105	67	117	116

Provides funding for three workyears of support service contractors for graphics, safety, and audio visual. The 1979 current estimate exceeds the budget estimate because the audio visual contract was transferred from the Installation Common Service function.

MANAGEMENT AND OPERATIONS

V. MANAGEMENT AND OPERATIONS	1,481	1,319	1,935	1,987
Basis of Fund Requirements				
A. Administrative Communications	308	346	380	379
B. Printing and Reproduction	25	25	35	36
C. Transportation	256	203	299	309
D. Installation Common Services	892	745	1,221	1,263
Total, Management and Operations	1,481	1,319	1,935	1,987

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	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
A. Administrative Communications	308	346	380	379

Includes estimates for Federal Telecommunications System (FTS), local telephone and exchange service, rental of TWX equipment, and three telephone operators provided under a support service contract.

1. Local telephone service 276

This funding covers the service for 575 main lines, 850 telephone instruments at the Center, and five main lines to Lancaster, California. Also included are the lease of switchboard equipment, commercial toll charges, and the support service contract for three telephone operators.

2. Long distance telephone service 100

This category provides funding to support 26 FTS lines.

3. Non-telephone communications 3

This funding provides teletype (TWX) service.

B. Printing and Reproduction	25	25	35	36

Includes the contractual publication of information and materials, and the related composition and binding operations. All common processes of duplication, including photostating, blue printing, and microfilming are included. The 1979 current estimate is increased due to higher cost of printing and reproduction materials and maintenance. Funding in 1980 remains at the same level as 1979.

C. Transportation	256	203	299	309

Provides funds for Government bills of lading issued to common carriers to move freight by rail, truck, water, and air; to fund shipments by United Parcel Services; and contract support for the Center's general purpose vehicles. The increase from the 1979 budget estimate to the 1979 current estimate is based on replacement of two passenger vehicles and two trucks.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
D. Installation Common Services	892	745	1,221	1,263

This category provides for physical examinations for DFRC pilots, reimbursement of the Air Force Flight Test Center for shuttle support, supplies, materials, and equipment to support the general administrative effort; rental of equipment; and the supply management support service contract. The increase in 1979 provides for incorporation of the supply management service into this function (previously shown under Facilities).

1. Pilot physicals 12

This category includes the costs for DFRC pilots physicals performed by the Lovelace Clinic in Albuquerque, New Mexico.

2. Air Force Flight Test Center (AFFTC) Support 110

This category includes reimbursement to the Air Force for services and miscellaneous supplies and materials provided in support of the Space Shuttle Orbital Flight Test (OFT) program.

3. Supplies and equipment 384

This category funds office supplies, and office equipment, and miscellaneous common service supplies and equipment.

4. Rental of equipment 50

Rented equipment is mostly office (e.g., photocopy type machines) that is more economical to rent than buy.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
5. Supply management services (25 workyears)				669

Provides funding for supply system operation by support service contractor. The increase from the 1979 budget to the 1980 budget estimate is based on the transfer of the contract support for supply management from Facilities Related Services.

6. Postage				38

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUGH L. DRYDEN FLIGHT RESEARCH CENTER

SUMMARY STAFFING	79	80
EXCEPTED	12	12
GS-16	2	2
GS-15	20	19
GS-14	39	38
ALL OTHER GS	405	388
WAGE BOARD	2	2
TOTAL PERMANENT	480	461

A REDUCTION IN FY 1979 OF 10 AND IN FY 1980 OF 19 HAS NOT YET BEEN DISTRIBUTED TO PERSONNEL CEILINGS IN THE INTERNAL ORGANIZATION STRUCTURE.

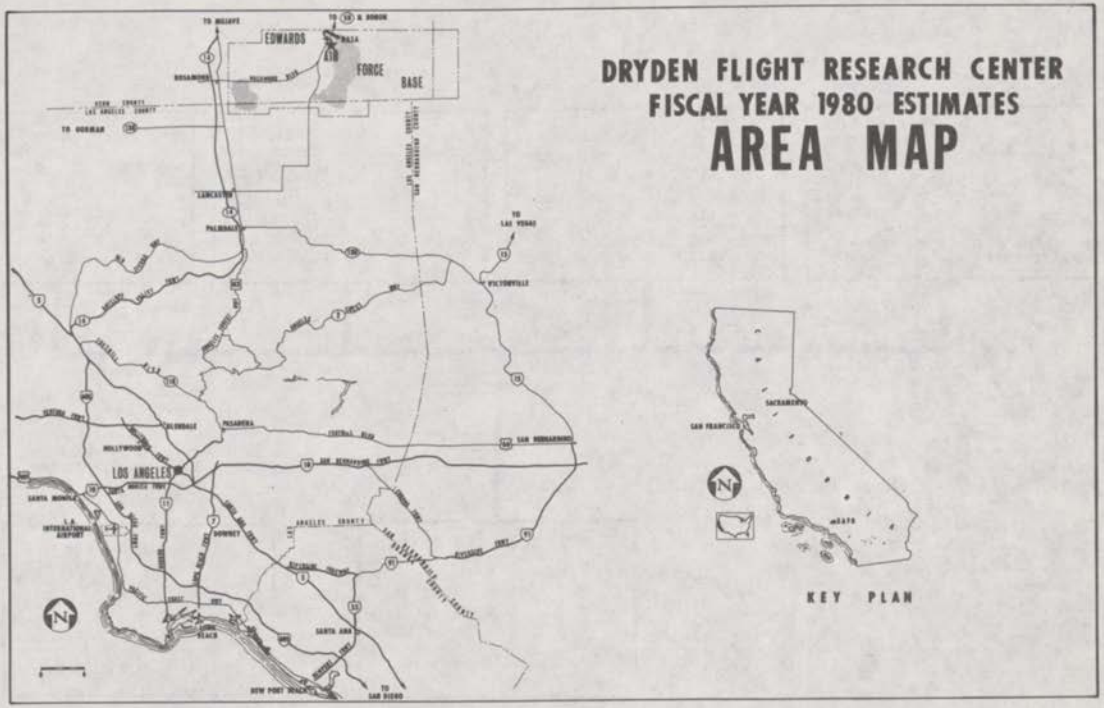
OFFICE OF THE DIRECTOR	79	80
EXCEPTED	4	4
GS-16	1	1
GS-15	2	2
GS-14	1	1
ALL OTHER GS	25	25
WAGE BOARD	-	-
TOTAL PERMANENT	33	33

DIRECTOR OF AERONAUTICS	79	80
EXCEPTED	4	4
GS-16	-	-
GS-15	6	6
GS-14	22	22
ALL OTHER GS	70	70
WAGE BOARD	-	-
TOTAL PERMANENT	102	102

DIRECTOR OF DATA SYSTEMS	79	80
EXCEPTED	1	1
GS-16	-	-
GS-15	4	4
GS-14	8	8
ALL OTHER GS	112	112
WAGE BOARD	-	-
TOTAL PERMANENT	125	125

DIRECTOR OF FLIGHT OPERATIONS	79	80
EXCEPTED	2	2
GS-16	1	1
GS-15	6	6
GS-14	5	5
ALL OTHER GS	139	139
WAGE BOARD	-	-
TOTAL PERMANENT	153	153

DIRECTOR OF ADMINISTRATION AND MANAGEMENT SUPPORT	79	80
EXCEPTED	1	1
GS-16	-	-
GS-15	2	2
GS-14	4	4
ALL OTHER GS	68	68
WAGE BOARD	2	2
TOTAL PERMANENT	77	77



DRYDEN FLIGHT RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES
AREA MAP

DRYDEN FLIGHT RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATE
LOCATION PLAN

PROPOSED FACILITIES

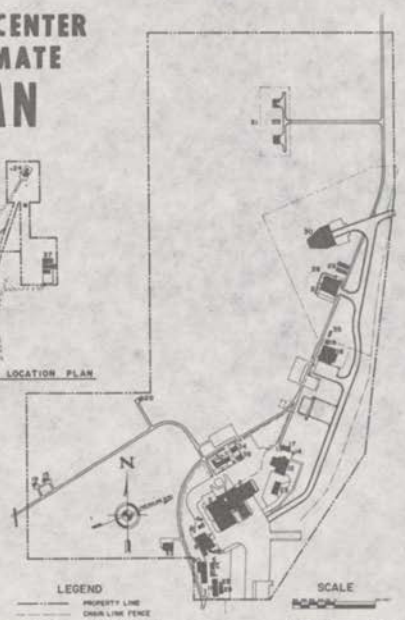
(A) DISCRETE PROJECTS
1. LARGE AIRCRAFT MAINTENANCE DOCK

(B) REHABILITATION AND MODIFICATION
1. REHABILITATION OF BUILDING 4800
2. MODIFICATION OF CENTRAL HYDRAULIC SYSTEM
3. MODIFICATION OF THE FIREWATER SYSTEMS

(C) LUMP-SUM REHABILITATION AND MODIFICATION
1. ENCLOSURE OF STAIRWELLS, BLDG. 4600
2. EROSION CONTROL, MISC. LOCATIONS
3. (DELETED)
4. SMALL PROJECTS
   a. FLIGHT OPERATIONS CREW ROOM RESTROOM MODIFICATIONS
   b. INSULATE BUILDINGS 4809, & 4810
   c. REHABILITATE LAWN SPRINKLER SYSTEM NORTH OF BUILDING 4800
   d. SOBER FIRE INSPECTION ITEMS, MISC. LOCATIONS
   e. PEDESTAL FOR THE HL-10 LIFTING BODY
   f. (DELETED)
   g. INSTALLATION OF A 6" DOMESTIC WATER LINE TO BUILDINGS 4809, & 4810
   h. MAINTENANCE & REPAIR OF THE SHUTTLE OVERLAND ROUTE, NOT SHOWN

(D) MINOR CONSTRUCTION
1. F-15 SIMULATION ENCLOSURE

REMOTE SITE LOCATION PLAN



EXISTING FACILITIES

1 LABORATORY BUILDING (4800)
2 AIRCRAFT CONSTRUCTION AND MODIFICATION HANGAR (4801)
3 MAIN HANGAR (4802)
4 AIRCRAFT TIRE REPAIR SHOP (4803)
5 TRAILER PARK AND MODULAR BUILDINGS
6 BOILER HOUSE (4686)
7 SHOPS (A.G.E., MODEL, BATTERY, GARAGE) (4806)
8 STORAGE BUILDING (4807)
9 WAREHOUSE NO 2 (4808)
10 WAREHOUSE NO 3 (4809)
11 WAREHOUSE NO 4 (4810)
12 FLIGHT LOADS RESEARCH BUILDING (4820)
13 PAINT SPRAY BUILDING (4821)
14 PAINT STORAGE BUILDING (4822)
15 COMMUNICATIONS BUILDING (4824)
16 MAINTENANCE DOCK (4826)
17 WOOD SHOP (4830)
18 WAREHOUSE NO 5 (4831)
19 RADAR BUILDING (4870)
20 100FT. TOWER, BORESITE TARGET ASSEMBLY AND EQUIP. BUILDING (4987)
21 CENTRAL STANDBY ELECTRICAL POWER FACILITY (4889)
22 STORAGE BUILDING (4804)
23 AIRCRAFT SERVICING DOCK (4823)
24 FPS-16 RADAR FACILITY (*982)
25 WAREHOUSE NO 6 (4827)
26 100 FT. TOWER, BORESITE TARGET ASSEMBLY AND EQUIP. BUILDING (4981)
27 SHUTTLE HANGAR (4833)
28 SHUTTLE SHOP (4834)
29 SHOP TRAILER COMPLEX (4854)
30 SHUTTLE MATING STRUCTURE (4860)
31 PROPELLANT FUEL AND OXIDIZER STORAGE AREA (4855)
32 INTEGRATED SUPPORT FACILITY (4825)
33 WAREHOUSE NO 7 (4832)
34 PAO TRAILERS
35 PUMP STATION NO 1 (4853)
36 TRAINING TRAILERS
37 GFSC STDN SPACE SHUTTLE ALT FACILITY (4818)
38 RCA EARTH STATION (4917)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
DRYDEN FLIGHT RESEARCH CENTER
EDWARDS, CALIFORNIA

FY 1980 ESTIMATE
LOCATION PLAN

SCALE: AS NOTED

MDH-D-000-79

1045

RPM 8-22

HUGH L. DRYDEN FLIGHT RESEARCH CENTER

FISCAL YEAR 1980 ESTIMATES



RPM 8-23

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1979 ESTIMATE

LANGLEY RESEARCH CENTER

DESCRIPTION

The Langley Research Center is located at Hampton, Virginia. It is situated between Norfolk and Williamsburg, Virginia, in the tidewater area of Hampton Roads. The Center utilizes 810 acres of Government-owned land, divided into two areas by the runway facilities of Langley Air Force Base. The West Area consists of 787 acres, all owned by NASA. The East Area comprises 23 acres under permit from the Air Force. Runways, some utilities, and certain other facilities are used jointly by NASA and the Air Force. In addition, there are 110 acres of NASA-owned land located in the city of Newport News, Virginia, and 3,276 acres under permit from the Department of Interior. The total acreage presently owned, under permit, or leased, is 4,196. The total capital investment of the Langley Research Center, including fixed assets in progress and contractor-held facilities at various locations, as of September 30, 1978, was $509,069,000.

CENTER ROLES AND MISSIONS

Langley Research Center (LaRC) continues to play a major role in the development of aeronautics and space technology in the United States.

Langley has developed recognized areas of technical excellence within the civil service staff and facilities of superior merit; that is, major technical facilities which constitute a national resource. The principal and supporting roles are:

PRINCIPAL

Long-Haul Aircraft Technology - developing a technology base for improving long-haul aircraft as a cost effective, safe and environmentally compatible transportation mode.

General Aviation Aircraft Technology - developing and maintaining an engineering technology base related to improving general aviation aircraft.

Fundamental Aerodynamics - advancing the general state of the art, both theoretical and experimental.

Acoustics and Noise Reduction - conducting research and developing a technology base related to reducing aircraft noise.

Aerospace Vehicle Structures and Materials - developing of a technology base for facilitating advances.

Avionics Technology - developing a technology base related to improving avionics.

Military Support - providing technical support to military aviation in areas consistent with other LaRC aeronautics roles and LaRC unique capabilities.

Advanced Space Vehicle Configurations Technology - developing a technology base related to advanced configurations, including advanced space transportation concepts.

Sensor and Data Acquisition Technology - developing a technology base for sensors and data acquisition devices.

Technology Experiments in Space - developing and managing the Long Duration Exposure Facility and Advanced Technology Laboratory. Defining and developing experiments in areas consistent with other LaRC space roles.

Environmental Quality Monitoring Technology - developing improved techniques for environmental monitoring. Includes research, experiment development/management, data analysis, and investigator management and specialized ground/aircraft investigations. Also includes development of Shuttle payloads related to environmental monitoring.

SUPPORTING

Rotorcraft Technology - contributing to the development of the technology base with emphasis on structures aeroelasticity, acoustics, noise, and avionics components.

Hypersonic Propulsion Systems - contributing to technology base of air breathing propulsion systems by advancing the state of the art of hypersonic propulsion.

Planetary Entry Technology - providing planetary and earth entry aerothermodynamics experimental and analytical data.

Computational Fluid Dynamics - contributing to the software technology base.

Upper Atmospheric Research - mission analysis, sensor development, data interpretation and utilization for remote sensing; contributing to model development.

Launch Vehicle Procurement - development and procurement for science/applications missions, including Scout launch vehicle and meteorological sounding rockets.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
I. Personnel and Related Costs	84,607	85,568	89,337	89,940
II. Travel	1,854	2,156	2,008	2,154
III. Facilities Services	8,148	9,321	9,268	10,192
IV. Technical Services	2,386	1,825	1,721	2,032
V. Management and Operations	5,024	5,709	5,662	5,940
Total, fund requirements	102,019	104,579	107,996	110,258

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Distribution of Permanent Positions by Program

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Direct Positions				
Space Transportation Systems	51	52	47	44
Space Shuttle	9	7	7	4
Expendable launch vehicles	42	45	40	40
Space Science	20	9	16	---
Physics and astronomy	16	9	16	---
Planetary exploration	4	---	---	---
Space and Terrestrial Applications	216	239	207	223
Space applications	204	226	195	211
Technology utilization	12	13	12	12
Aeronautics and Space Technology	2,034	2,019	2,004	1,983
Aeronautical research and technology	1,459	1,444	1,470	1,470
Space research and technology	575	575	534	513
Subtotal, direct positions	2,321	2,319	2,274	2,250
Center Management and Operations Support Positions	750	750	741	740
Total, permanent positions	3,071	3,069	3,015	2,990

PROGRAM DESCRIPTION

SPACE SHUTTLE — 4 Permanent Positions (Civil Service)

In 1980, civil service personnel will be working on test and evaluation of propellant dynamics.

EXPENDABLE LAUNCH VEHICLES — 40 Permanent Positions (Civil Service)

The expendable launch vehicle program at Langley provides centralized procurement of the Scout Launch Vehicle. In 1980 civil service personnel will support a program which includes the procurement of launch vehicle hardware, launch services, engineering, and maintenance.

The 1980 launches under this program will be conducted from sites located at the Western Test Range in California, and the San Marco platform off the coast of Kenya, Africa.

SPACE APPLICATIONS — 211 Permanent Positions (Civil Service)

The space applications program at Langley is characterized by a research program that is a national resource for understanding environmental problems and for developing related monitoring systems. The Center's technical expertise is widely recognized in the areas of remote sensing of the terrestrial atmospheric trace species and analytical atmospheric modeling. In the area of Upper Atmospheric Research, Langley civil service personnel will continue its study of the earth's atmosphere to assess any changes caused by man and to determine whether or not there is any associated change in the transmission of solar radiation. Effort will be given to defining an Atmospheric Lidar System for the Spacelab/Shuttle which will perform atmospheric measurements of trace constituent, clouds, aerosols and temperature in the troposphere and stratosphere, and for measuring trace species, winds and temperature in the mesosphere and troposphere.

The Center's sensor development program encompasses the broadest possible range of advanced remote sensing techniques, including correlation gas filter radiometry and interferometry, laser heterodyne radiometry, and lidar.

A significant improvement in our understanding of man's impact on the stratosphere and climate will be obtained from the combination of Langley developed statistical/theoretical models and the comprehensive global data set provided by spaceborne sensors such as Nimbus-G, SAGE, and the Halogen Occultation Experiment (HALOE). The HALOE instrument will measure stratospheric species involved in ozone destruction by chlorine chemistry.

Studies of the Earth's radiation budget will be fundamental to the understanding of climate phenomena. Langley has the responsibility for the science, sensor development, and data management for the Earth Radiation Budget Satellite System, a prime element in NASA's support of the National Climate Program. Preliminary radiation budget studies, based on Nimbus data, have explored the relationship of radiation budget to such climatological parameters as cloudiness, snow and ice cover, and sea surface temperature.

A unique Langley marine research capability of coupled lab spectral signature, field test, data processing algorithm and display and predictive model research has been demonstrated. The Langley program will provide the technology base for design of future integrated remote sensing systems for increasing our understanding of water pollution problems.

TECHNOLOGY UTILIZATION — 12 Permanent Positions (Civil Service)

The overall objective of the NASA Technology Utilization program is to enhance economic growth and contribute to the technological solution of public problems through the transfer of new technology resulting from aeronautical and space research and development efforts to the non-aerospace segments of the economy.

In 1980, civil service personnel will provide the following support:

1. Expedite the application of new technology by compressing the time required from generation of technology to its use in the economy.

2. Encourage the use of aerospace technology in non-aerospace segments of the economy having problems amendable to technological solutions.

3. Understand more fully the technology transfer process and its impact and systematically manage and optimize the process.

AERONAUTICAL RESEARCH AND TECHNOLOGY — 1,470 Permanent Positions (Civil Service)

The aeronautical research and technology program at Langley is characterized by the dynamic interaction between a broad spectrum of technical disciplines, the application of discipline research to specific technology requirements, demonstrations of particular technology applications and the indepth look at future technology requirements. The diversity of activities in such disciplines as materials, structures, flight stability and control, avionics, and aerodynamics provides the expertise to pursue the broader problems such as those involved in the terminal configured vehicle and aircraft energy efficiency technology programs. The unique wind tunnel and computing facilities at Langley compliment the expertise of the technical staff to produce a broad cohesive program in aeronautical research.

The aerodynamics activity at Langley encompasses extensive theoretical, experimental, and applications activities. Basic work in fluid and flight mechanics involves theoretical and experimental determination of aerodynamic flows and complex aircraft motions. The program utilizes the unique Langley capabilities made possible by the STAR Computer and recently developed cryogenic wind tunnel testing techniques which provide the capability of simulating full-scale conditions.

Aspects of the problems which are studied include airfoil and wing design, flowfield analysis, configuration design processes, noise and analysis, propulsion system integration, fuel efficiency, flight dynamics, and economic feasibility. In 1980, precursor aerodynamic tests will be carried out in the 0.3-meter transonic cryogenic tunnel in preparation for utilization of the National Transonic Facility currently under construction. Tunnel testing techniques will be further enhanced by combining the technology developed for non-optical positioning sensing of models with the superconducting coil technology to provide for the design and construction of an advanced magnetic balance and suspension system. The STAR Computer will be used in the areas of far-field jet noise, 3-D potential flow programs, and in the solution of 2-D and 3-D Navier-Stokes equations. Generation and documentation of the aerodynamic behavior of new airfoils will be furthered by the continued definition of the aerodynamic characteristics of a range of supercritical airfoils. Application of advanced transonic theories to the design of improved 3-D wings will be continued and evaluated by wind tunnel tests. Wind tunnel and flight tests will be continued on general aviation aircraft configurations having the potential for practical stall immunity and means for spin avoidance. An improved data base for the aircraft noise prediction computer program will be developed so that noise contours can be predicted within 1.5dB accuracy. Other activities in the acoustics and noise reduction research include research on atmospheric propagation, noise predictions, and community impact and annoyance produced by aircraft noise. In the area of aircraft energy efficiency technology, major activities include continuation of work required for the design and testing of a laminar flow control wing box, cover panel and ducting, and for the design of a laminar flow control compatible supercritical airfoil section for flight test evaluation; the establishment of design data for high aspect ratio supercritical wings; investigations of high-lift aerodynamics configurations for advanced transports; and the evaluation of performance benefits achievable by incorporating winglets and wing tip extensions to wide-body transports. This technology also has application to improved mission performance for advanced maneuvering air combat aircraft and missile systems and is being investigated in relation to supersonic and hypersonic configuration concepts. In the area of supersonic configurations, improved aerodynamic platforms will be experimentally determined by subsonic, transonic, and supersonic wind tunnel tests.

The materials and structures effort is directed at the development of new and improved structural materials, manufacturing processes, and design technology to improve the structural efficiency, reliability, and durability, and to reduce design costs of airframes and components. This activity is focused on research on advanced composite materials, computer aided analysis and design technology, and development of analytical

or semiempirical fatigue and life prediction methodology. Use of active controls for minimization of aeroelastic response, reduced static stability, and minimization of gust and maneuver loads is being pursued in both theoretical and wind tunnel studies.

Emerging technological advances in computer systems are being exploited to significantly increase the utility and reduce the cost of engineering computations. A finite element computational device using microprocessor components will be defined in 1980 that is capable of reducing computational costs and/or times by a factor of ten over present devices.

A short term, intensive effort is being pursued to quantify the potential for accidential release of carbon fibers into the atmosphere as a result of the crash and subsequent burning of commercial transport aircraft having carbon fiber composite components and to perform a comprehensive risk analysis of the electrical hazards associated with such a carbon fiber release.

The avionics work at Langley includes technology development in aircraft guidance and navigation, aircraft control systems, crew station avionics, and integration and interfacing techniques. Also, major efforts in aircraft flightpath management and operations technology and active controls technology for conventional takeoff and landing (CTOL) are being conducted in this program area. The work includes requirements analyses, design studies, systems and component technology development, ground simulation and technology validation, and proof-of-concept validation through experimental flight programs. The Langley expertise in the avionics area is being applied to terminal configured vehicle systems and operations technology, broadly applicable technology for development of low-cost Global Positioning System (GPS) navigation hardware and software, advanced control laws for various aircraft classes, intersystems communications networks for enhanced interfacing and integration of functions within an aircraft, and advanced technology improved display media and pilot/system interfaces in aircraft cockpits. Emphasis in 1980 will be on investigations of the capacity, efficiency, and safety potential of cockpit-displayed air traffic information concepts with elements of an advanced air traffic control system, the development of technology for enhanced function and hardware integration to increase aircraft systems reliability and reduce operating costs, and the investigation of concepts and technology which will result in highly accurate aircraft navigation capability utilizing the GPS. Other avionics technology applications are also found in work on advanced digital flight control systems, fluidics instrumentation for general aviation aircraft, and the development of mathematical tools to investigate and enhance reliability prediction and assessment, control algorithm design, and pilot describing functions.

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SPACE RESEARCH AND TECHNOLOGY

513 Permanent Positions (Civil Service)

The space research and technology program at Langley is characterized by work in several discipline areas and the application of this discipline expertise to current and future technology requirements. Longer range studies are directed at defining the technology requirements for future space systems and missions.

The objective in the materials area is to establish and demonstrate the required technology for application of advanced materials for a wide variety of space applications. Material systems and applications include: high temperature composites with long life capability for use as structural materials in future space transportation systems; high temperature metallic materials for thermal protection systems; and high stiffness, low weight, low thermal expansion composites for large, long-life space structures. Environmental effects on the mechanical and physical properties of materials are being studied utilizing specialized facilities and laboratories. An integral part of the research activity is the definition of new experimental testing and research facility requirements which will assure that the reliability and durability of future space structures can be adequately predicted and assessed. Other research efforts are underway to develop new or improved materials to meet projected requirements and to define manufacturing, forming, and joining processes to further improve structural efficiency.

The goal of the activities in the area of structures is to provide validated analysis and design methodology, design concepts, and dynamics and control methodology required for efficient long-life space transportation and payload structures. High temperature metallic heat shield concepts and actively cooled structural and propulsion concepts for advanced Space Transportation Systems are being derived and evaluated using specialized laboratories and wind tunnels. A complete radiation heat transfer, large deflection, and non-linear materials property analysis capability will be available in 1981. Analysis, design, and loads determination methodology for deployable and erectable large space platforms, antennae and booms are being studied as part of a multi-Center, multidisciplinary program for advanced technology. Experimentally verified analysis and design capability for composite space structures which are 10 to 100 times larger than existing flight hardware will be developed by mid-1981. By mid-1982, an improved structural analysis methodology for substantially improved computational efficiency will be developed and verified. It will include the effects of plasticity, large deflections, large rotations, and other sources of nonlinear behavior, and will require application of evolving advanced numerical techniques, computer software and computer hardware.

An extensive program in electronic component technology development, data processing and sensor development is conducted at Langley. Sensor developments include laser back scatter and fluorescence techniques for water quality measurements, continuously tuneable infrared laser techniques, and high power/high pressure tuneable gas lasers for the measurement of low concentration atmospheric constituents. In 1980 Langley will demonstrate the reliability of tuneable laser diodes to meet the requirements of a solar occultation Laser Heterodyne

Spectrometer experiment to measure stratospheric constituents in the 9-12um region, and will design and evaluate an array of microwave radiometer receivers for high-resolution (±1 km) oceanographic sensing. Specific devices required to support the development of a charged coupled device onboard data processor are being developed and evaluated. The broad objective of this work is to develop an onboard processor technology base for remote sensing vehicles with the potential of leading to a 1,000-fold decrease in the density of data sent back to Earth processing stations. The evaluation of a solid state data storage system using bubble domain technology is underway at Langley. The overall objective is to provide an adequate bit solid state data storage system suitable for replacing tape recorders in many aerospace vehicle applications. Other space electronics technology efforts are focused on detectors for remote sensing (e.g., infrared and pyroelectric devices), spacecraft attitude control (using magnetically suspended momentum storage or vernier pointing devices), and multipurpose, user-oriented, software development, verification and validation techniques.

The objectives of the Langley program in entry technology are to develop the aerothermodynamic technology required for the design and operation of advanced vehicle systems for space and global transportation, and to provide space shuttle support. The objectives are being met through the application of analytical techniques and unique Langley facilities in the areas of Earth orbit transportation, aerodynamics, heat transfer, real gas effects, planetary entry, radiative heating and hypervelocity gas dynamics. Theoretical and experimental efforts in the areas of ablation product radiation and absorption, highly blown shock layer probe flight mechanics, and mass loss and shape change will be pursued to develop a sufficient data base to minimize planetary mission cost, maximize scientific return and ensure a high probability of mission success.

The Langley programs in Space Technology Shuttle Payloads involve a variety of tasks focused on extending basic research and technology development into the space environment when economically feasible, and/or when the objectives can be achieved only in space.

CENTER MANAGEMENT AND OPERATIONS SUPPORT — 740 Permanent Positions (Civil Service)

Center Management and Operations Support is defined as that support or services being provided to all Langley Research Center organizations which cannot be directly identified to a benefiting program or project. The civil service personnel involved are:

Director and Staff - The Center Director, Deputy Director, and immediate staff, e.g., Legal, Patent Counsel, Equal Opportunity, Public Affairs, and Safety.

Management Support - Includes a wide range of activity categorized as management support for programs and functional organizations for the entire Center. Specific functions include resource and budget management, program control, contracting and procurement, personnel management, property management, financial management, resource control and management information systems and analysis.

Operations Support - This is a broad spectrum of activity that is required to maintain and operate facilities, buildings, and equipment; and to provide the normal housekeeping services and logistics support for the personnel who manage and conduct the affairs of the Center. Specific activities are:

Maintenance and operation of all buildings and facilities
Date processing and computer support
Reliability and quality assurance
Centerwide security and protection
Fire protection
Custodial services
Logistics support including transportation, supplies, etc.
Medical care of employees
Photographic and graphic support

PERSONNEL AND RELATED COSTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
I. PERSONNEL AND RELATED COSTS	84,607	85,568	89,337	89,940
Basis of Fund Requirements				
A. Compensation and Benefits				
1. Compensation				
a. Permanent positions	75,202	75,573	78,864	79,276
b. Nonpermanent	987	1,126	1,264	1,211
c. Reimbursable detailees	4	34	---	---
d. Overtime and other compensation	342	510	536	544
Subtotal, Compensation	76,535	77,243	80,664	81,031
2. Benefits	7,572	7,693	8,041	8,214
Subtotal, Compensation and Benefits	84,107	84,936	88,705	89,245

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
B. Supporting Costs				
1. Transfer of personnel	39	95	95	105
2. Personnel training	461	537	537	590
Subtotal, Supporting Costs	500	632	632	695
Total, Personnel and Related Costs	84,607	85,568	89,337	89,940
A. Compensation and Benefits	84,107	84,936	88,705	89,245
1. Compensation	76,535	77,243	80,664	81,031
a. Permanent positions	75,202	75,573	78,864	79,276

The funds shown above will support 2,990 permanent positions in 1980, a reduction of 25 positions from the 1979 level. The increase in cost from the 1979 budget estimate to the 1979 current estimate is due primarily to the October 1978 pay raise partially offset by savings from the reduction of 54 permanent positions.

Basis of Cost for Permanent Positions

In 1980 the cost of permanent positions will be $79,276,000, an increase of $412,000 over 1979. This increase results from the following:

Cost of permanent positions in 1979		78,864
Cost increase in 1980		+2,147
Within grade advances and career development		
Full year effect of 1979 actions	+643	
Partial year effect of 1980 actions	+739	
Full year effect of October 1978 pay increase	+110	
Decrease in reimbursements	+44	
Two additional paid days in 1980	+611	

Cost decreases in 1980		-1,735
Turnover savings and abolished positions:		
Full year effect of 1979 actions	-777	
Partial year effect of 1980 actions	-958	
Cost of permanent positions in FY 1980		79,276

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
b. Nonpermanent positions				
1. Cost	987	1,126	1,264	1,211
2. Workyears	117	135	143	137

The 1979 current estimate increases from the 1979 budget estimate due to the addition of a part-time employment program. The 1980 estimate reflects a slight decrease from 1979 as a result of the absorption of the part-time program into the permanent position ceiling. This 1980 estimate will support the following programs as shown:

Distribution of Nonpermanent Workyears by Program

Program	Workyears
Cooperative training programs	77
Summer programs	11
Youth opportunity programs	38
Other temporaries	11
Total	137

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
c. Reimbursable detailees	4	34	---	---

The current estimate in 1979 and 1980 reflects the phasing out of the appointment of a reimbursable detailee who participated in experimental flight programs.

d. Overtime and other compensation	342	510	536	544

The use of overtime and other compensation is limited to emergency repairs and work that cannot be accomplished during normal working hours. This includes the monitoring of on-site contracts being performed during off-duty hours and wind tunnel work required at night to take advantage of off-peak rates. The increase from the 1979 budget estimate to the current estimate is due to the 1979 pay increase, partially offset by the savings from the reduction in permanent positions. The 1980 estimate is essentially level from 1979.

2. Benefits	7,572	7,693	8,041	8,214

Following are the amounts of contribution by category:

Category of Costs				
Civil Service Retirement Fund	5,285	5,305	5,563	5,680
Employee life insurance	328	340	345	349
Employee health insurance	1,564	1,678	1,729	1,803
Workmen's compensation	275	289	289	300
FICA	19	28	30	29
Incentive awards	48	53	53	53
Severance pay	53	---	32	---
Total	7,572	7,693	8,041	8,214

The increase from the 1979 budget estimate to the current estimate is due to the October 1978 pay increase partially offset by the savings from the reduction of 54 permanent positions. The increase in 1980 over the 1979 current estimate is related to the increases in personnel compensation and is partially offset by savings due to the manpower reductions.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
B. Supporting Costs	500	632	632	695
1. Transfer of personnel	39	95	95	105

Transfer of personnel costs include actual expenses involved in the movement and temporary storage of employees' household goods, subsistence and temporary expenses, real estate costs and miscellaneous moving expenses. The 1980 estimate reflects the same level of activity as 1979 adjusted for rising real estate costs.

2. Personnel training	461	537	537	590

The increase in the 1980 budget estimate from the 1979 current estimate reflects the full year effect of rate increases in the Langley pilot training contract.

TRAVEL

II. TRAVEL	1,854	2,156	2,008	2,154
Basis of Fund Requirements				
A. Program Travel	1,315	1,435	1,375	1,478
B. Scientific and Technical Meeting Travel	247	250	250	265
C. Management and Operation Travel	292	471	383	411
Total, Travel	1,854	2,156	2,008	2,154

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
A. Program Travel	1,315	1,435	1,375	1,478

Program travel is directly related to the accomplishment of the Center's mission and accounts for 69 percent of the travel budget for 1980. Travel for program purposes reflects the continuing effort in space research, aircraft technology, flight simulation, fluid mechanics, airborne science and applications, and space applications. The decrease between the 1979 budget estimate and current estimate is a result of an overall travel reduction. The increase from 1979 to 1980 reflects the level of program activity at the Center.

B. Scientific and Technical Meeting Travel	247	250	250	265

Scientific and technical meeting travel permits employees to participate in meetings and technical seminars with other representatives of the aerospace community. This participation allows them to benefit from exposure to technological advances outside LaRC, as well as to present both accomplishments and problems to their associates. Many of the meetings are working panels convened to solve certain problems for the benefit of the Government. The increase from 1979 to 1980 reflects the need to provide those employees with technological expertise the opportunities necessary to keep abreast of the latest state of the art in their respective fields, and represents roughly the same level of travel as in 1979.

C. Management and Operations Travel	292	471	383	411

Management and operations travel is used for the direction and coordination of general management matters. It includes travel in such areas as personnel, financial management, and procurement activities; travel of the Center's top management to NASA Headquarters and other NASA Centers; and local transportation. The decrease between the 1979 budget estimate and the 1979 current estimate reflects a reduction based on 1978 experience and a reduction taken in general administrative travel. The 1980 estimate reflects a continuation of the 1979 level of travel.

FACILITIES SERVICES

Langley Research Center (LaRC) is located on 787 acres of grounds in a complex made up of laboratory and office type buildings as well as research wind tunnels.

This complex encompasses 2,087,601 gross square feet of building space including 11 major buildings. Also included are some 18 major technical facilities. This physical plant houses an average daily on-Center population of 4,200 to 4,500 personnel. Many of the test facilities are utilized on more than one shift/or during off peak hours.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
III. FACILITIES SERVICES	8,148	9,321	9,268	10,192
Basis of Fund Requirements				
A. Maintenance and Related Services				
1. Facilities	598	339	585	624
B. Custodial Services	1,538	1,958	1,894	1,980
C. Utility Services	6,012	7,024	6,789	7,588
Total, Facilities Services	8,148	9,321	9,268	10,192
A. Maintenance and Related Services				
1. Facilities	598	339	585	624

This activity reflects a decision by Center management to provide an adequate level of administrative facility maintenance and repair in order to maintain ageing facilities and equipment. This activity also provides for 12 workyears of effort to accomplish grounds maintenance. The increase in the 1980 request provides for negotiated contractor wage rate increases for maintenance at the level provided in 1979.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
B. Custodial Services	1,538	1,958	1,894	1,980

This activity involves 107 workyears of effort at LaRC to provide for janitorial and security services. The 1980 estimate provides for the full year effect of previously negotiated wage rate increases in 1979 for janitorial and security guard services at the current level.

C. Utilities Services	6,012	7,024	6,789	7,588

Included in this item is the purchase of electric service from VEPCO, fuel oil from a local supplier, and water and sewage charges. Also included are funds to procure steam services from the USAF-Langley under an interagency support agreement.

A breakdown of the utilities costs is as follows:

1. Electricity (150,000 mWh)	6,000
2. Fuel oil (2,985,000 gals.)	1,278
3. Steam (USAF)	215
4. Water and sewage	95

The 1979 current estimate reflects a reduction of five million kilowatt hours of electricity due to revised programmatic requirements. The 1980 estimate reflects the full year effect of rate increases at the same level provided in 1979.

TECHNICAL SERVICES

IV. TECHNICAL SERVICES	2,386	1,825	1,721	2,032

Basis of Fund Requirements

A. Automatic Data Processing				
1. Equipment	56	101	106	311
2. Operations	2,062	1,311	1,275	1,368
Subtotal	2,118	1,412	1,381	1,679

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
B. Scientific and Technical Information				
1. Library	80	85	90	101
2. Education and information	188	328	250	252
Subtotal	268	413	340	353
Total, Technical Services	2,386	1,825	1,721	2,032
A. Automatic Data Processing	2,118	1,412	1,381	1,679

Funds for the Center's business computer complex which provides the accounting and management information data required by the Center and NASA are provided for in this function. Included are equipment lease, purchase and maintenance; paper and other expendable supplies; small miscellaneous contracts; and a 33 workyear level of effort support service contract for programming and operations.

1. Equipment	56	101	106	311

This activity includes the lease and purchase of equipment associated with Langley's business computer complex. The 1980 increase reflects an equipment update for the central processor unit.

2. Operations	2,062	1,311	1,275	1,368

This estimate includes ADP equipment maintenance, supplies, and the support service contract for programming and operations. The increase in 1980 reflects the full year effect of rate increases in 1979 for programming and operations services.

B. Scientific and Technical Information	268	413	340	353

This estimate includes the purchase of books, materials, and supplies, and for support service contract assistance in the operation of the technical library. Also included are public information services and operation of the Visitor Information Center.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
1. Library	80	85	90	101

Eight workyears of support contract effort are for the operation of the Center's technical library. The 1980 estimate reflects an increase for the full year effect for previously negotiated contractor wage rates at the same level of effort provided in 1979.

2. Education and information	188	328	250	252

Funding for all the Center's public affairs activities is included in this estimate. Included are are operation of the Visitor Information Center; coordination of tours and special events; construction and transportation of exhibits; and other miscellaneous educational and information programs. The 1980 estimate is essentially level from 1979.

MANAGEMENT AND OPERATIONS

V. MANAGEMENT AND OPERATIONS	5,024	5,709	5,662	5,940
Basis of Fund Requirements				
A. Administrative Communications	1,069	2,147	1,164	1,182
B. Printing and Reproduction	182	159	169	177
C. Transportation	1,120	1,337	1,271	1,360
D. Installation Common Services	2,653	2,066	3,058	3,221
Total, Management and Operations	5,024	5,709	5,662	5,940

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
A. Administrative Communications	1,069	2,147	1,164	1,182

This estimate includes funds for local telephone and exchange costs; Federal Telecommunications System (FTS) service; and datafax and telegraph service. The decrease in the 1979 current estimate is primarily a result of moving the estimate for postage to the installation common services function. The 1980 estimate provides for the full year effect of rate increases for communication services.

1. Local telephone service..... 793

This estimate provides for local telephone and exchange costs. The 1980 estimate provides for the full year effect of rate increases.

2. Long distance telephone services..... 380

These funds provide for long distance telephone service for the FTS. The 1980 estimate provides for the full year effect of rate increases for this service.

3. Nontelephone communications..... 9

Included in this activity are costs for other miscellaneous communications such as teletype and datafax services. The 1980 estimate provides for the full year effect of rate increases for these services.

B. Printing and Reproduction.....	182	159	169	177

This estimate provides for special printing and reproduction, supplies, and a four workyear support service contract effort for reproduction services. The 1980 estimate provides for the full year effect of a previously negotiated wage increase in support service contract costs.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
C. Transportation	1,120	1,337	1,271	1,360

This activity includes the operation, maintenance, and purchase of motor vehicles; shipping transportation and freight charges; a 26 workyear support service contract effort for pickup and delivery of freight, furniture, and other bulk objects; and a seven workyear support service contract for operation and maintenance of the NASA-1 aircraft. This effort also includes all of the NASA-1 aircraft fuel, equipment, and expendable supplies. The 1980 estimate provides for the full year effect of a previously negotiated wage increase in support contractor costs and the full year effect of rate increases for other services.

D. Installation Common Services	2,653	2,066	3,058	3,221

These funds will provide for 76 workyears of support service contract effort for medical services, mail delivery, stock issue and warehousing, and other general administrative support. Also included are are the rental and maintenance of office copy machines and equipment, minority programs, and other administrative services and supplies. The increase in the 1979 current estimate is a result of moving the estimate for postage to this function from the administrative communications function. The 1980 estimate provides for the full year effect of previously negotiated rate increases in support service contracts at the same level of effort provided in 1979.

1. Center management and staff..... 384

This function includes 20 workyears of support service contract effort and general supplies and equipment purchases for all administrative support organizations at the Center. The 1980 estimate reflects the full year effect of previously negotiated wage rate increases in support contract costs at the same level of effort provided in 1979.

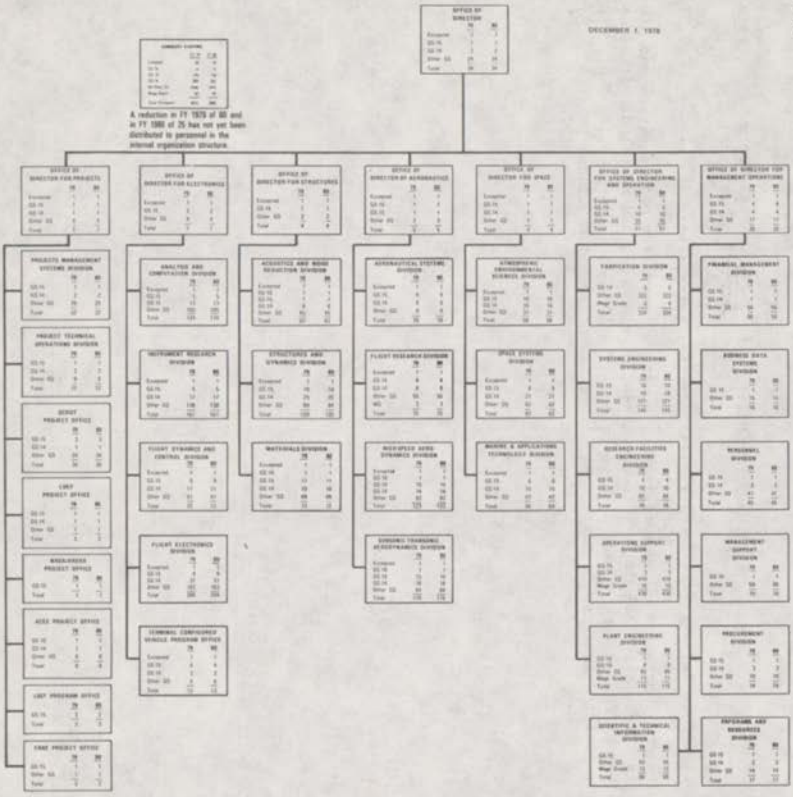
2. Medical services..... 461

This function includes 11 workyears of effort in the Center's occupational and environmental health services that provide dispensary services, emergency ambulance service, medical examinations, health physics and industrial hygiene services. The 1980 estimate provides for the full year effect of a previously negotiated increase in the cost of support contractor medical services at the same level of effort provided in 1979.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
3. Installation support services				2,376

This function includes 45 workyears of support service contract effort for mail delivery and stock issuance and warehousing operations. Also included are the purchase, maintenance, and rental of office copy machines, typewriters and other office equipment, and postage costs. The 1980 estimate provides for the full year effect of a previously negotiated increase in cost of support contractors and continued level of effort in other services.

LANGLEY RESEARCH CENTER



DECEMBER 1, 1978

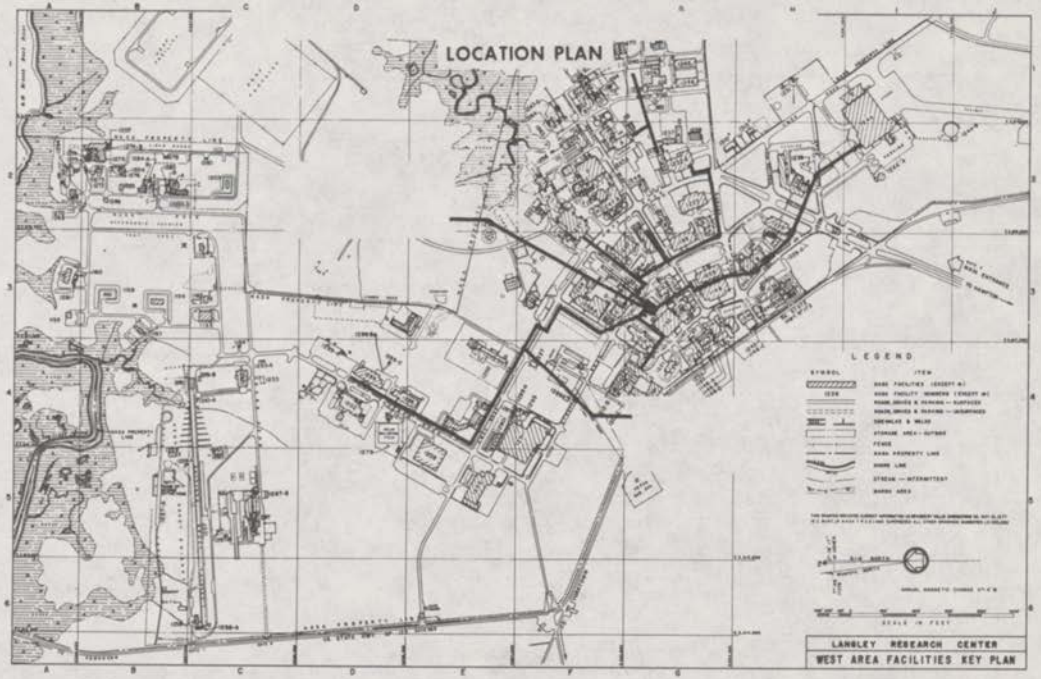
A reduction in FY 1979 of 60 and in FY 1980 of 25 has not yet been distributed to personnel in the internal organization structure.



LANGLEY RESEARCH CENTER AND VICINITY

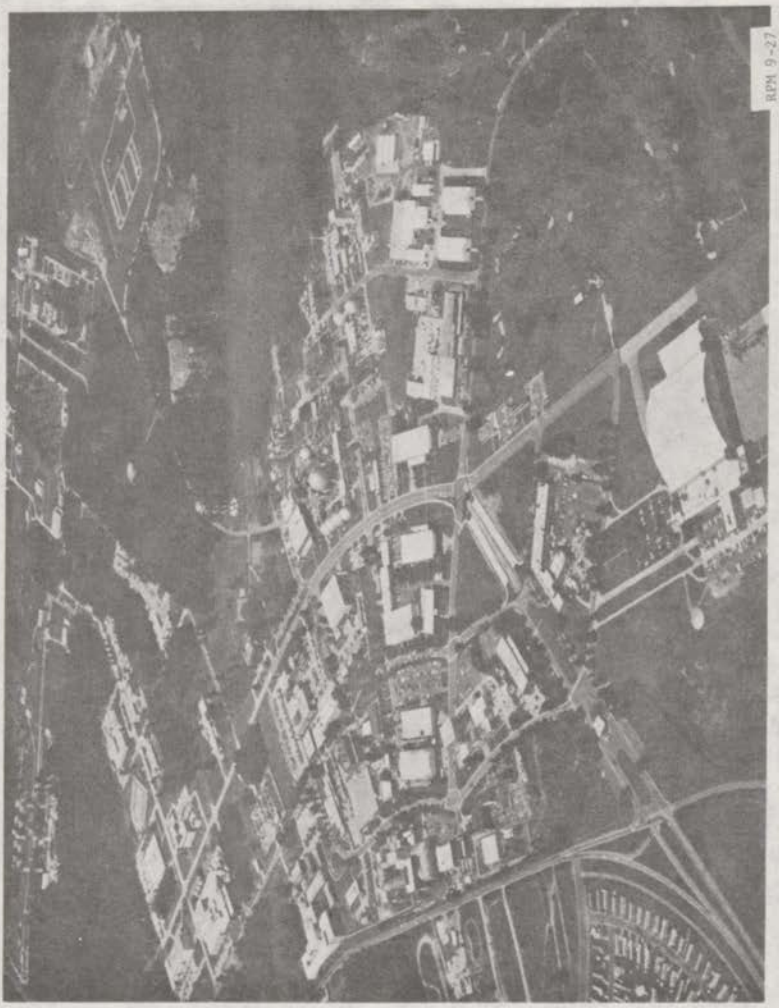
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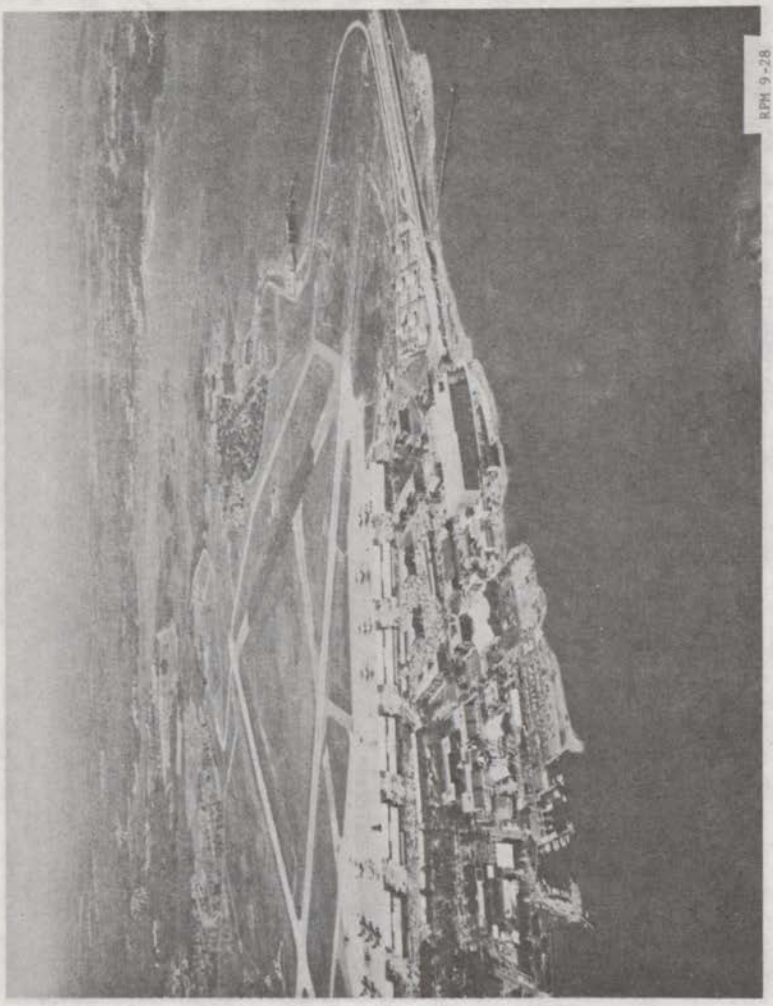
LANGLEY RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES



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RPM 9-26


RPM 9-27


RPM 9-28

LEWIS RESEARCH CENTER

DESCRIPTION

The Lewis Research Center occupies two sites in north central Ohio. The original site, established in 1941 adjacent to the Cleveland-Hopkins International Airport, has 366 acres including 14 acres leased from the City of Cleveland. There are over 100 buildings, including wind tunnels, test chambers, laboratories and other research facilities.

The Plum Brook Station established in 1956, is located south of Sandusky, Ohio, about fifty miles west of Cleveland, on land formerly occupied by the Plum Brook Ordnance works. There are 8,005 acres owned and an additional 47 acres in easements. There are 77 buildings and 99 concrete storage bunkers. A 100 KW Electric Wind Turbine Generator Facility designed to be operated remotely is in operation for a program jointly sponsored by the Department of Energy and NASA. During 1975, consistent with our future research and technology needs, the principal facilities were placed in a standby mode.

The total capital investment of the Lewis Research Center and the Plum Brook Station, including fixed assets in progress and contractor-held facilities at various locations as of September 30, 1978, was $429,724,000.

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CENTER ROLES AND MISSIONS

The Lewis Research Center was established in 1941 as an aircraft engine research laboratory to meet the immediate needs at that time to develop superior aircraft propulsion systems. Since then, Lewis has developed and constructed many outstanding facilities for testing full-scale aircraft engines and engine components, chemical rocket engines, electric propulsion, space and terrestrial power generation systems and space communication systems. The principal and supporting roles are:

PRINCIPAL

Aeronautics - Development of an advanced technology base for high performance civil and military aircraft propulsion systems within environmental, safety, and energy restraints. Development of a technology base to advance the state of the art in aeronautical propulsion systems and components, including internal engine noise reduction, high temperature materials and structures, improved engine efficiency, pollution control, internal computational fluid mechanics and providing technical support to military aviation.

Launch Vehicle Procurement - management and operation of the Centaur launch vehicle system for scientific and applications missions for other federal government and commercial users.

Space Propulsion Systems Technology - development and maintenance of the space propulsion systems technology base, including associated structures and materials work.

Space Energy Processes and Systems Technology - development and maintenance of technology base, including associated structures and materials work.

Energy Technology - conducting energy-related research and development, primarily on a reimbursable basis, with broad emphasis on solar, gas turbine, ground propulsion, and other appropriate terrestrial energy systems.

SUPPORTING

High Power Communications Systems Technology - development of high power communications technology, including high power microwave and millimeter-wave components and systems oriented towards satellite-based applications. Includes flight experiment development and management.

Environmental Observations - development of remote sensing technology and systems for applications to water quality in the Great Lakes and to the characterization, mapping, and movement of lake ice and ocean ice.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
I. Personnel and Related Costs	71,998	80,253	78,334	80,524
II. Travel	1,002	1,187	1,126	1,208
III. Facilities Services	8,912	9,705	10,026	10,894
IV. Technical Services	732	565	418	429
V. Management and Operations	2,272	2,070	2,609	2,745
Total, fund requirements	84,916	93,780	92,513	95,800

Distribution of Permanent Positions by Program

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Direct Positions				
Space Transportation Systems	144	129	129	105
Space Shuttle	8	---	---	---
Expendable launch vehicles	136	129	129	105
Space Science	43	---	24	4
Physics and astronomy	25	---	6	---
Planetary exploration	14	---	14	---
Life sciences	4	---	4	4
Space and Terrestrial Applications	121	133	121	125
Space applications	115	127	115	119
Technology utilization	6	6	6	6
Aeronautics and Space Technology	2,028	2,091	2,009	2,031
Aeronautics research and technology	1,308	1,427	1,325	1,347
Space research and technology	370	314	334	334
Energy technology	350	350	350	350
Subtotal, direct positions	2,336	2,353	2,283	2,265
Center Management and Operations Support Positions	585	585	575	570
Total, permanent positions	2,921	2,938	2,858	2,835

PROGRAM DESCRIPTION

EXPENDABLE LAUNCH VEHICLES — 105 Permanent Positions (Civil Service)

The Centaur Launch Vehicle program provides launch vehicles and launch operations for automated space missions. The program includes the procurement of vehicle systems hardware, launch services, engineering and management support as well as maintenance and operation of ground support equipment.

In 1980, civil service personnel working on the Centaur Launch Vehicle program will continue to support the launching of both government and commercial payloads. Currently, four Atlas-Centaur launches are scheduled in support of the Navy FLTSATCOM and INTELSAT V programs for COMSAT.

LIFE SCIENCES — 4 Permanent Positions (Civil Service)

The Lewis Research Center has applied its expertise in materials, high-speed rotating machinery, fluid systems, controls, and miniature devices to medical applications for treating diseases of the human eye. With the support of the National Eye Institute (HEW), the Lewis Research Center has developed two significant devices: first, a surgical instrument which can quickly and safety remove any type of human eye cataract and, second, an intraocular pressure reduction and regulation system for use prior to intraocular surgery. Patent applications have been filed for both these instruments. They are now being tested and verified for commercialization by two U.S. eye institutes.

SPACE APPLICATIONS — 119 Permanent Positions (Civil Service)

Space Applications at Lewis Research Center consists of space communications and environmental observations. In 1980, Lewis civil service personnel will continue to support these programs as follows:

Communications - Lewis is studying the capabilities and costs of various advanced satellite communications systems concepts directed at providing additional frequency bands and improved communication service. The studies are being focused on the needs of the public and private sectors both nationally and internationally. Lewis is working on experimental systems with possible application to both the ground and space segments of any future advanced communications systems. Presently orbiting the earth is the joint U.S./Canadian communications Technology Satellite, which utilizes a high power transmitter developed by Lewis. Lewis has begun studies and a technology development program to expand the communication bands usable for communications in order to meet the increasing needs for additional frequencies. This program is directed at the 20 to 30 gigacycles band.

Environmental Observations - Lewis is presently assisting communities in the thermal scan of cities to determine the heat loss of structures and buildings for the purpose of encouraging reduced consumption of our Nation's energy resources. The thermal scanning techniques are also being applied to the real time determination of ocean surface temperatures by remote (airplane or satellite borne) sensors.

Program milestones include verification of remote sensing data for organic and inorganic matter in the Great Lakes, completing the evaluation of coastal zone color scanner algorithms, and complete tests to determine the ability to detect and classify icebergs and ships in the North Atlantic.

TECHNOLOGY UTILIZATION — 6 Permanent Positions (Civil Service)

In 1980, Lewis civil service personnel in the Technology Utilization Program will be involved in transfer of new knowledge and innovative technology resulting from NASA R&D programs for application in industry, the public sector, and medicine. The primary objectives are to (1) increase the return on the national investment in aerospace R&D, (2) shorten the time from discovery to application, (3) aid the movement of new knowledge to potential users, and (4) contribute to the development of improved means of transferring the new knowledge to other places of potential applications. Examples of areas of present programs are: applications of nickel-zinc batteries (miner's caps, wheelchairs), surface texturing by ion beams (teeth implantation), automated insolation reporter (solar thermal input used by industry), material science (obliterated serial number restoration), and communications (central medical emergency dispatch).

AERONAUTICS RESEARCH AND TECHNOLOGY — 1,347 Permanent Positions (Civil Service)

Lewis' major responsibility within aeronautics is aeronautical propulsion. The general goals of Lewis are to provide the advanced technology base for developing high-performance civil and military aeronautical propulsion systems which are economical, fuel-conservative, and reliable, and which operate with minimum environmental impact. The civil service personnel in 1980 will be involved in conducting the ongoing program at the Center as described below.

In aeronautical propulsion-related research the goals are to develop an understanding of the physical phenomena related to propulsion systems and components including: aeroelasticity phenomena in turbo-machinery, heat transfer characteristics within turbine blading, friction and wear phenomena, low and high temperature composite materials, fatigue failure mechanisms, emission characteristics in reciprocating and turbine engines, alternate fuels characterization, noise generation mechanisms, and integrated control concepts.

The major goal in the components technology program is to advance the state of the art in engine components including: composite fan blades, low aspect ratio compressor stages, core turbine cooling, blade clearance controls, advanced transmissions, prevaporizing combustors, two-dimensional nozzles, supersonic inlets, high speed propellers, bearings, seals, and instrumentation.

In engine systems technology, Lewis is studying problems encountered in complete engines and propulsion systems including: engine performance at altitude, inlet flow distortion effects, dynamic component interactions, thrust augmentation, advanced control systems, techniques for reduced fuel consumption, engine emission and noise reduction, propulsion system-airframe interactions, and aviation safety technology associated with propulsion systems.

Within the aeronautics program at Lewis, work is being performed on a number of major project areas including: materials for advanced turbine engines, energy efficient engine, variable cycle engine, stratospheric cruise emission reduction, engine component improvement, quiet short-haul research aircraft, supersonic cruise research, advanced turboprops, and advanced helicopter transmissions.

SPACE RESEARCH AND TECHNOLOGY — 334 Permanent Positions (Civil Service)

The major roles of the Lewis Research Center in Space Research and Technology are to advance the state of the art and maintain a technology base for advanced propulsion and power systems, including associated materials and structures work and space power processing. The civil service personnel in 1980 will be used in the activities described below.

The Lewis space propulsion programs include chemical and electric propulsion technology and component and systems development. The chemical propulsion program emphasizes advanced engine systems and components required for future space systems beyond the capability of the Space Shuttle. Improved components and methods of life prediction are being developed and demonstrated, advanced fuel-oxidant combinations are being tested, and complete engine systems tests are being conducted. Technology developments include advanced cooling techniques, fabrication techniques and materials for rocket chambers and nozzles, and advanced high pressure fuel/oxidant feed systems.

Electric propulsion supports both primary propulsion and auxiliary propulsion applications. The primary propulsion technology program consists of further thruster performance verification tests, performance testing of supporting power processor systems to deliver power to the thruster and its controls, and the integration testing of complete thruster systems, including the thruster, power processor, propellant storage and distribution system, thruster gimbal mechanism, controllers, and thermal control systems. Auxiliary electric propulsion meets spacecraft requirements for maneuvering, station keeping and attitude control. The present program objectives are to verify the performance of a one-millipound thruster, develop and test thruster power systems, and perform complete system verification tests. A technology-readiness experiment is being developed for launch into orbit.

Space power generation studies include solar photovoltaic and electrochemical energy conversion. The photovoltaic program is directed towards an improvement in solar cell efficiency, reduced cost, and improved operating life. Electrochemical research and development supports extended operating life and improved energy density for space batteries and fuel cell components and systems. Lewis is also conducting a program to advance the state of the art of microwave power amplifiers for potential future applications in communications and power transmission.

The interactions of the space plasma environment with high-voltage power systems and components are being studied and technology is being developed to control these interactions and prevent power system failures.

The Lewis program in space materials technology emphasizes the development of improved materials for advanced space power generation, propulsion and communications systems. Studies include space environmental effects on superalloys and composites, and lubrication problems in mechanical components. Investigation of fundamental material properties affecting metal matrix composites, high temperature combustion corrosion, and electrochemical processes are also included.

ENERGY TECHNOLOGY — 350 Permanent Positions (Civil Service)

Civil service personnel will be involved in ongoing energy research and development projects related to meeting program milestones of 1980 and subsequent years.

Lewis provides a supporting research and technology base in terrestrial energy conversion and advanced ground propulsion under sponsorship of the Department of Energy. Presently under development are large wind turbogenerators (200 to 2,500 kilowatts) to help meet public power requirements and photovoltaic power systems where their application appears practical. Other programs at Lewis supporting stationary power generation include improved coal-fired utility gas turbine and magnetohydrodynamic system studies. Energy storage systems for stationary power applications are also under development.

Ground propulsion systems development at Lewis includes advanced heat engines and electric vehicles. The major thrust of the heat engine project is to advance the technology level of the auto gas turbine and Stirling engine propulsion systems such that their application to automotive propulsion would be practical and cost effective. The electric vehicle project provides near-term technology improvements to existing electric vehicle components and systems.

Program milestones for 1980 include completion of design and initiation of hardware fabrication for advanced electric and hybrid vehicle propulsion systems; the testing of ceramic components in auto gas turbine engines for automotive application; and completion, installation and initial operation of a two and one-half megawatt wind turbine.

CENTER MANAGEMENT AND OPERATIONS SUPPORT — 570 Permanent Positions (Civil Service)

Center Management and Operations Support is defined as that support or services being provided to all Lewis Research Center organizations which cannot be directly identified to a benefiting program or project. The civil service personnel involved are:

Director and Staff - The Center Director, Deputy Director and immediate staff, e.g., Technology Utilization, Equal Opportunity, Public Affairs, Reliability and Quality Assurance, Shuttle Assessment Office and Chief Scientist.

Management Support - Includes a wide range of activity categorized as management support for programs and functional organizations for the entire Center. Specific functions include resource and budget management, legal and patent counsel, program control, contracting and procurement, personnel management, property management, financial management, environmental health, resource control and management information systems and analysis.

Operations Support - This is a broad spectrum of activity that is required to maintain and operate facilities, buildings, and equipment; and to provide the normal housekeeping services and logistics support for the personnel, who manage and conduct the affairs of the Center. Specific activities are:

- Maintenance and operation of all buildings and facilities
- Data processing and computer support
- Reliability and quality assurance
- Centerwide security and protection
- Fire protection
- Custodial services
- Logistics support including transportation, supplies, etc.
- Medical care of employees
- Photographic and graphic support

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PERSONNEL AND RELATED COSTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
I. PERSONNEL AND RELATED COSTS	71,998	80,253	78,334	80,524
Basis of Fund Requirements				
A. Compensation and Benefits				
1. Compensation				
a. Permanent positions	63,640	70,880	69,172	71,057
b. Nonpermanent positions	800	700	855	909
c. Overtime and other compensation	890	1,046	1,008	1,062
Subtotal, Compensation	65,330	72,626	71,035	73,028
2. Benefits	6,373	7,201	6,933	7,078
Subtotal, Compensation and Benefits	71,703	79,827	77,968	80,106
B. Supporting Costs				
1. Transfer of personnel	35	66	56	58
2. Personnel training	260	360	310	360
Subtotal, Supporting Costs	295	426	366	418
Total, Personnel and Related Costs	71,998	80,253	78,334	80,524
A. Compensation and Benefits	71,703	79,827	77,968	80,106
1. Compensation	65,330	72,626	71,035	73,028

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
a. Permanent positions	63,640	70,880	69,172	71,057

The funds shown will support 2,858 permanent positions in 1979 and 2,835 permanent positions in 1980. The current estimate for 1979 reflects a decrease from the budget estimate. This change is the net effect of an increase in reimbursable activity, a reduction in personnel, and the increased cost due to the October 1978 pay raise. The increase in 1980 is due to the full year effect of the 1978 pay raise plus two additional days which is partially offset by the reduction in permanent civil service workforce.

Basis of Cost for Permanent Positions

In 1980 the cost of permanent positions will be $72,057,000 an increase of $1,885,000 over 1979. This increase results from the following:

Cost of permanent positions in 1979		69,172
Cost increase in 1980		+3,338
Within grade advances and career development		
Full year effect of 1979 actions	+780	
Partial year effect of 1980 actions	+696	
Full year effect of 1979 pay increases	+1,233	
Two extra days in 1980	+629	
Cost decreases in 1980		-1,453
Turnover savings		
Full year effect of 1979	-460	
Partial year effect of 1980 actions	-869	
Change in reimbursables	-124	
Cost of permanent positions in 1980		71,057

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
b. Nonpermanent positions				
1. Cost	800	700	855	909
2. Workyears	91	98	103	98

The increase in 1979 from the budget estimate to the current estimate reflects 1978 experience, the effect of the October 1978 pay raise and the experimental part-time employment program. The decrease in workyears is due to the absorption of the part-time program into the permanent position ceiling. The 1980 plan supports a relatively constant temporary program. This effort will support the following programs as shown below:

Distribution of Nonpermanent Workyears by Program

Program	Workyears
Cooperative training program	40
Summer programs	10
Youth opportunity programs	23
Other temporaries	25
Total	98

c. Overtime and other compensation	890	1,046	1,008	1,062

The 1980 increase in overtime and night differential is related to the full year cost of 1978 pay increases. Overtime hours remain constant.

2. Benefits	6,373	7,201	6,933	7,078

Following are the amounts of contribution by category:

Category of Costs	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Civil Service Retirement Fund	4,381	4,986	4,842	4,974
Employee life insurance	250	305	246	251
Employee health insurance	1,400	1,586	1,463	1,489
Workman's compensation	226	240	240	248
FICA	25	20	30	30
Incentive awards	68	60	75	80
Other benefits	4	4	5	6
Severance pay	19	---	32	---
Total	6,373	7,201	6,933	7,078

The increase in 1980 is due to the increase in permanent compensation.

B.	Supporting Costs	295	426	366	418
1.	Transfer of personnel	35	66	56	58

The increase in transfer of personnel in 1979 and 1980 over 1978 is due to increased recruiting to meet the requirements of maintaining a constant complement.

2.	Personnel training	260	360	310	360

About 38% of the training cost is for technically oriented training. Another 33% is provided specifically for the scientific and engineering staff. The remaining 29% supports other programs, including administrative and clerical. Training in 1978 was restricted due to budget limitations. The reduction in 1979 from the budget estimate to the current estimate is a result of the 1978 cutback. The 1979 and 1980 levels include funds for announced increases in tuition, primarily in the minority training programs.

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TRAVEL

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
II. TRAVEL	1,002	1,187	1,126	1,208
Basis of Fund Requirements				
A. Program Travel	814	992	931	1,004
B. Scientific and Technical Meeting Travel	114	119	125	130
C. Management and Operations Travel	74	76	70	74
Total, Travel	1,002	1,187	1,126	1,208
A. Program Travel	814	992	931	1,004

Program travel is directly related to the accomplishment of the Center's mission, and accounts for approximately 83% of the travel costs. It provides funds necessary to manage major contractual programs in Aeronautical Research and Technology, space propulsion, materials research and development, and Energy Technology. Program travel is essential to the management and procurement of launch vehicles. The increase in 1980 is due to the increased travel in support of the Aeronautical Research and Technology program.

B. Scientific and Technical Meeting Travel	114	119	125	130

Scientific and technical meeting travel permits employees to participate in meetings and seminars with other representatives of the aerospace community. This participation allows them to benefit from exposure to technological advances outside LeRC, as well as to present both accomplishments and problems to their associates. Many of the meetings are working panels convened to solve certain problems for the benefit of the Government.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
C. Management and Operations Travel	74	76	70	74

Management and operations travel is required for the direction and coordination of general management matters. It includes travel in such areas as personnel, financial management, procurement, travel of the Center's top management to NASA Headquarters and other NASA Centers, and local transportation.

FACILITIES SERVICES

Lewis Research Center (LeRC) occupies 366 acres of grounds and a complex of facilities made up of test and office-type buildings and aircraft engine research facilities.

This complex encompasses 2,211,493 gross square feet of building space including 12 major buildings. Also included are eight major technical facilities. This physical plant houses an average daily on-Center population of 3,000 to 3,300 personnel. Many of the test facilities are utilized on more than one shift and/or during off-peak hours.

The estimates also include certain resources associated with plant needs at its component installation, the Plum Brook Operations Division.

III. FACILITIES SERVICES	8,912	9,705	10,026	10,894
Basis of Fund Requirements				
A. Maintenance and Related Services				
1. Facilities	1,703	745	901	930
2. Equipment	93	35	75	76
Subtotal	1,796	780	976	1,006
B. Custodial Services	1,802	1,980	1,929	2,075

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
Utilities Services	5,314	6,945	7,121	7,813
Total, Facility Services	8,912	9,705	10,026	10,894
A. Maintenance and Related Services	1,796	780	976	1,006
1. Facilities	1,703	745	901	930

This activity involves the LeRC facilities as well as those of Plum Brook Station. It provides for 14 workyears of effort to provide for maintenance, repair, and alterations of buildings and grounds. 1978 maintenance was exceptionally high due to necessary repairs caused by severe winter damage. Some of these repairs included fixing sidewalks and curbs, roads, roofs, and tuck pointing. The increase in 1979 from the budget estimate to the current estimate is due to the deferral of some maintenance work into 1979. The services provided are level from 1979 to 1980.

2. Equipment	93	35	75	76

1978 reflects a special one-time purchase of shop equipment. Both 1979 and 1980 represent a return to the 1977 level.

B. Custodial Services	1,802	1,980	1,929	2,075

This activity involves 122 workyears of effort at LeRC to provide for security, janitorial, and fire protection services. The increase in the 1980 estimate is primarily due to negotiated increases in contractor wage rates. The major services are distributed as follows:

1. Security (43 workyears)	739
2. Janitorial (63 workyears)	907
3. Other services (16 workyears)	429

This activity includes rubbish disposal, fly ash removal, and industrial cleaning of walls, lights and windows on an as-needed basis, laundry services, and supplies and materials. Custodial services for the Plum Brook Station are included here.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
C. Utilities Services	5,314	6,945	7,121	7,813

The 1980 estimate covers the projected consumption at the Lewis Research Center and the Plum Brook Test Station. Electrical power is provided by the local utility company with locally procured fuel oil being used as a central plant fuel at both sites. Natural gas is the primary heating fuel used at Lewis with fuel oil and coal as back-up depending on the market situation. Fifteen workyears of contractor effort provide for the operation of the central heating plant. Since the 1979 budget estimate utility consumption figures have been revised. The increase in 1979 from the budget estimate to the current estimate is due to increased utility costs, primarily electricity, coal and natural gas. There is a planned reduction in utility consumption of 12 percent from the 1979 budget estimate. In 1980 there is a further decrease in consumption; however, the saving is exceeded by increased rates. The distribution of the utilities budget is as follows:

1. Electricity (160,000 MW/Hrs.)	5,840
2. Natural Gas (280,600 K cu. ft.)	769
3. Fuel Oil (214,000 gals.)	96
4. Coal (7,000 tons)	501
5. Steam Plant Support Contractor (15 workyears)	427
6. Water and Sewage	180

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
IV. TECHNICAL SERVICES	732	565	418	429
Basis of Fund Requirements				
A. Automatic Data Processing				
1. Equipment	14	22	29	13
2. Operations	182	217	189	213
Subtotal	196	239	218	226
B. Scientific and Technical Information				
1. Library	44	30	43	43
2. Education and Information	492	231	157	160
Subtotal	536	261	200	203
C. Shop Support and Other Services	---	65	---	---
Total, Technical Services	732	565	418	429
A. Automatic Data Processing	196	239	218	226

The funding provides for administrative data processing including equipment maintenance, programming and operation.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
1. Equipment	14	22	29	13

Equipment rental and maintenance are included in this activity.

2. Operations	182	217	189	213

Seven support contractor workyears make up the services of the on-site keypunch support contract. The decrease in 1979 from the budget estimate to the current estimate is due to 1978 experience. The 1980 increase is due to support contractor wage increases.

B. Scientific and Technical Information	536	261	200	203

Included in this activity are the purchase of books, supplies, and materials required for the operation of the Lewis Research Center library. Also provided are the public information services and the operation of the Visitor Information Center.

1. Library	44	30	43	43

The increase in 1979 from the budget estimate to the current estimate is due to 1978 experience; purchases are expected to remain constant through 1980.

2. Education and Information	492	231	157	160

The 1978 amount includes one-time costs of completing several exhibits in the Visitor Information Center. The normal level effort of services is provided in 1979 and 1980.

C. Shop Support and Services	---	65	---	---

In the 1979 budget estimate, supplies and materials included in this function have been recategorized to the Management and Operations function.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
V. MANAGEMENT AND OPERATIONS	2,272	2,070	2,609	2,745
Basis of Fund Requirements				
A. Administrative Communications	601	810	740	751
B. Printing and Reproduction	31	28	5	5
C. Transportation	322	578	589	601
D. Installation Common Services	1,318	654	1,275	1,388
Total, Management and Operations	2,272	2,070	2,609	2,745
A. Administrative Communications	601	810	740	751

This estimate provides for leased lines and equipment for local and long distance telephone service, Federal Telecommunications Service (FTS), trunklines for Federal communications, and non-telephone communications including telex, advanced records system, datafax and teleconference equipment. The decrease in 1979 from the budget estimate to the current estimate is due to the recategorization of postage to the Installation Support Services function. This is partially offset by rate increases from the Ohio Bell Company. The increase in 1980 is related to estimated rate increases in service.

1. Local telephone service 356

This activity includes the leased lines and equipment necessary to serve the Center. This includes approximately 1,785 instruments, 800 stations and 40 incoming and outgoing lines.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
2. Long distance telephone service				380
Commercial long distance costs, FTS costs, and overseas calls are included in category.				
3. Non-telephone communications				15
This estimate includes funds for one telex instrument, one GSA teletype, advanced record systems unit, one "rapidfax", one "datafax", four teleconference units, and oceanic cable service.				
B. Printing and Reproduction	31	28	5	5
This activity includes general printing services and printing of the Lewis News. The decrease in 1979 is due to the Lewis News no longer being printed inhouse.				
C. Transportation	322	578	589	601
This function includes services for moving and hauling, packing and crating, special maintenance of motor vehicles, procurement, aircraft operation and maintenance. Two support contractor workyears are utilized for heavy equipment maintenance at Plum Brook.				
D. Installation Common Services	1,318	654	1,275	1,388
This funding provides for 42 workyears of support contractor effort to support Center management and staff activities, medical services, and various installation support services. The increase in 1979 from the budget estimate and the current estimate is due to three main factors: the recategorization of postage in this function; a new medical program that was begun in 1978 at LeRC which involves an increase of eight support contractor workyears; and, an increase of two support contractor workyears in the medical program at the Plum Brook Station. In 1980, the level of services being provided is unchanged.				
1. Center management and staff				82
This funding provides for a support service contract for center management and administrative records keeping.				

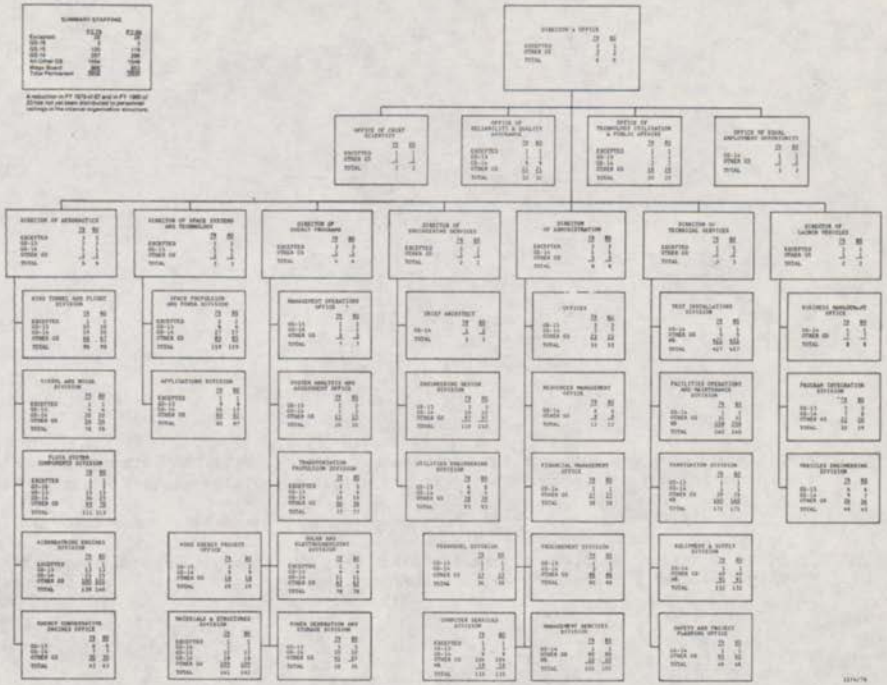
	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
2. Medical services				438

This category includes the cost of our health unit support service contract and medical supplies and routine medical examinations provided through our in-house occupational medicine program.

3. Installation support services				868

This function includes the support service contracts for mail and package distribution services, and the stock issuance and warehousing operations. Also included are the purchase and maintenance of office machines and equipment, and postage.

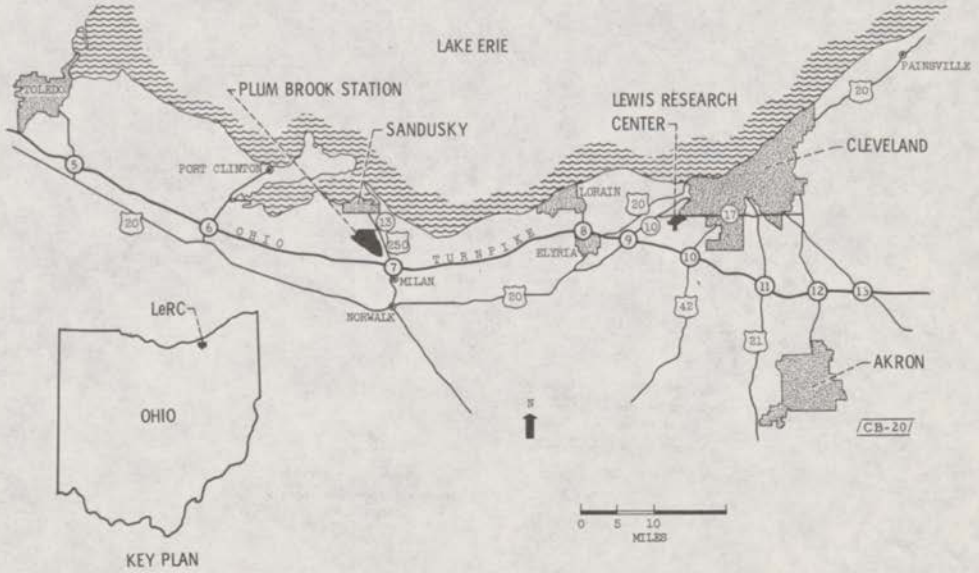
National Aeronautics and Space Administration
Organization and Staffing Chart
LEWIS RESEARCH CENTER
Cleveland, Ohio



RPM 10-22

LEWIS RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES

AREA MAP

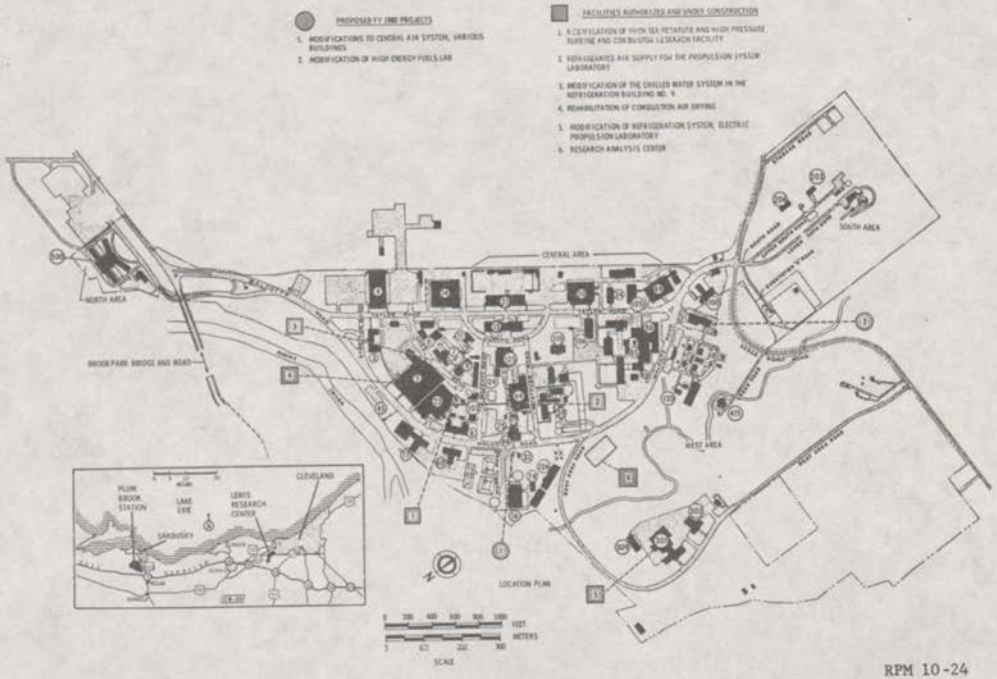


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LEWIS RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES

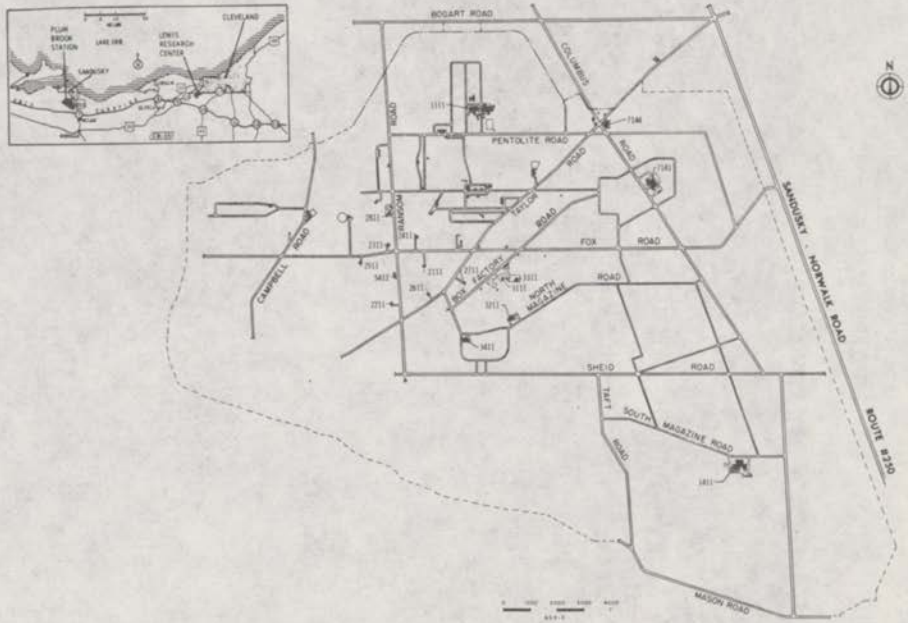
LOCATION PLAN



RPM 10-24

LEWIS RESEARCH CENTER
PLUM BROOK STATION
FISCAL YEAR 1980 ESTIMATES

LOCATION PLAN



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LEWIS RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES

CLEVELAND FACILITIES

RPM 10-26



LEWIS RESEARCH CENTER
FISCAL YEAR 1980 ESTIMATES

PLUM BROOK FACILITIES



RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1980 ESTIMATES

NASA HEADQUARTERS

DESCRIPTION

NASA Headquarters is located at 400 Maryland Avenue, SW, Washington, DC, and also occupies other buildings in the District of Columbia, Maryland and Virginia. Except for some office space leased in the District of Columbia and a storage area in Virginia, personnel occupy Government-owned buildings.

HEADQUARTERS ROLES AND MISSIONS

The mission of the National Aeronautics and Space Administration Headquarters is to plan and provide executive direction for the programs authorized by the Congress and to implement the national objectives stated in the National Aeronautics and Space Act of 1958, as amended. These objectives are to:

1. Extend our knowledge of the Earth, its environment, the solar system, and the universe;
2. Expand practical applications of space technology;
3. Develop, operate, and improve manned and unmanned space vehicles;
4. Improve the civil and military usefulness of aeronautical vehicles, while minimizing their mental effects and energy consumption.
5. Disseminate pertinent findings to potential users; and
6. Promote international cooperation in peaceful activities in space.

The following offices at Headquarters assist management in carrying out the technical aspects of the mission:

Office of Space Transportation Systems - Responsible for the research, development and operations of space flight programs including the Space Shuttle, which will enable the U.S. Government, foreign, and commercial users to place a wide variety of payloads into Earth orbit in the 1980's. The Space Transportation System consists of the Shuttle, the first reusable Earth-to-orbit vehicle, and the Spacelab, an experiments payload carrier being developed by the European Space Agency. The Space Transportation Systems Office also has program responsibility for expendable launch vehicles and for conducting advanced studies.

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Office of Space Science - Responsible for scientific research and development effort to increase scientific knowledge and understanding of the universe and its component parts and the effects of the space environment on living systems.

Office of Space and Terrestrial Applications - Responsible for the conduct of research and development activities leading to demonstration and transfer of space-related technology and capabilities which can be effectively applied and used for practical benefits on Earth. These research and development activities involve the following program areas: resource observation, environmental observation, space communications, materials processing in space, and technology utilization.

Office of Aeronautics and Space Technology - Responsible for the aeronautical, space and energy research and technology programs. The aeronautics program develops technology culminating in safer, more efficient, economical and environmentally acceptable air transportation systems which are responsive to national needs. The space research and technology program provides a technology base which anticipates the technical needs and provides technology options for future space activities. The energy program provides an interface with and support to the Department of Energy in the execution of interagency related activities conducted by NASA. The Office of Aeronautics and Space Technology is also responsible for coordinating the total NASA program of supporting research and technology related to specific programs and projects to insure a comprehensive, properly balanced agency research and technology program.

Office of Space Tracking and Data Systems - Responsible for the development, implementation, and operation of tracking, data acquisition, command, communications, and data processing facilities, systems and services required for support of all NASA flight missions. This office also provides centralized planning and systems management for the administrative communications of NASA installations.

Research and Program Management (R&PM) funding is used to support the staffing and operation of NASA Headquarters in Washington, DC. The overall capability of the agency to operate effectively is dependent upon sufficient R&PM funds to hire and support a Headquarters workforce to give direction and coordination to ensure accomplishment of the agency mission. This portion of the budget is prepared to reflect requirements to accomplish the following objectives:

- To provide a balanced Agency Headquarters workforce capable of planning and providing executive direction to the programs authorized by the Congress and implementing the national objectives stated in the National Aeronautics and Space Act of 1958, as amended.

- To provide a balanced Headquarters supporting workforce capable of providing necessary administrative, operational and logistical support to those Headquarters elements concerned with carrying out the mission of the National Aeronautics and Space Administration.

- To provide adequate facilities to house the workforce in Washington, DC.

- To provide for technical, administrative and logistical support necessary to facilitate accomplishment of NASA goals and objectives as administered by the Headquarters.

The Headquarters workforce consists of a professional and clerical staff organized into the program offices indicated above and appropriate supporting staff offices. Funding for pay, travel and necessary support services are included in this portion of the budget submission. Each office is assigned a function consistent with carrying out the NASA Headquarters mission. The number of personnel authorized to an office is determined by Management based on the approved personnel ceiling for the Agency and the functions to be performed. The composition of the staff of an office is determined by the head of the office based on the office ceiling and the function to be performed. All personnel are appointed and paid consistent with classification standards established by the Office of Personnel Management. Overall Agency direction is provided by the Administrator, and his personal office staff. He is assisted by heads of special and technical staff offices which perform functions necessary to the effective operation of the Agency and the Headquarters. Such offices are concerned with administration and management or support of the Headquarters. Included are such offices as the Chief Scientist, Chief Engineer, Comptroller, General Counsel, External Relations, Management Operations, Aerospace Safety Advisory Panel, Equal Opportunity, Procurement and the Inspector General. The Headquarters currently has eleven (11) centers throughout the U.S. which perform agency operational missions under direction of the Headquarters staff.

The Headquarters supporting workforce is organized to perform agency and Headquarters roles, although some elements perform only Headquarters support functions. For example, the Office of Headquarters Administration provides for support to the personnel and physical plant in Washington while the Office of Personnel Programs provides both Headquarters and Agency direction and support with respect to personnel requirements.

Facilities consist of the General Services Administration (GSA) leased space at FB-6, FB-10B and Reporters Building in Washington, DC, and a storage area in Virginia, and the scientific and technical information facility in nearby Maryland.

Technical support required by Headquarters is performed primarily by support service contractors. Currently, contractors support Headquarters automatic data processing and the scientific and technical information program. Administrative and logistical support is provided by the in-house workforce assisted by miscellaneous contract services. Such support includes communications, printing, supplies, materials, equipment, transportation, occupational medicine and health, and miscellaneous administrative support services.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
I. Personnel and Related Costs	52,528	54,317	55,768	55,893
II. Travel	2,385	2,545	2,494	2,697
III. Facilities Services	4,988	5,610	5,576	5,662
IV. Technical Services	15,195	15,082	15,289	15,989
V. Management and Operations	6,029	6,978	6,919	7,256
Total, fund requirements	81,125	84,532	86,046	87,497

Distribution of Permanent Positions by Program

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Direct Positions				
Space Transportation Systems	196	203	196	196
Space Shuttle	77	75	77	70
Space flight operations	105	117	105	112
Expendable launch vehicles	14	11	14	14

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Space Science	104	104	104	101
Physics and astronomy	51	39	51	48
Planetary exploration	30	46	30	30
Life sciences	23	19	23	23
Space and Terrestrial Applications	112	111	111	114
Space applications	92	92	92	95
Technology utilization	20	19	19	19
Aeronautics and Space Technology	159	155	159	159
Aeronautical research and technology	81	77	81	81
Space research and technology	58	58	58	58
Energy technology	20	20	20	20
Space Tracking and Data Systems	46	42	46	46
Tracking and data acquisition	46	42	46	46
Subtotal, direct positions	617	615	616	616
Management and Operations Support Positions	914	920	888	877
Total, permanent positions	1,531	1,535	1,504	1,493

PERSONNEL AND RELATED COSTS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
I. PERSONNEL AND RELATED COSTS	52,528	54,317	55,768	55,893
Basis of Fund Requirements				
A. Compensation and Benefits				
1. Compensation				
a. Permanent positions	45,916	46,930	48,135	48,236
b. Nonpermanent	906	1,175	1,205	1,203
c. Reimbursable detailees	249	279	310	314
d. Overtime and other compensation	255	277	342	343
Subtotal, Compensation	47,326	48,661	49,992	50,096
2. Benefits	4,422	4,553	4,658	4,691
Subtotal, Compensation and Benefits	51,748	53,214	54,650	54,787
B. Supporting Costs				
1. Transfer of personnel	163	220	220	234
2. Office of Personnel Management Services	78	138	138	140
3. Personnel training	539	745	760	732
Subtotal, Supporting Costs	780	1,103	1,118	1,106
Total, Personnel and Related Costs	52,528	54,317	55,768	55,893

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
A. Compensation and Benefits	51,748	53,214	54,650	54,787
1. Compensation	47,326	48,661	49,992	50,096
a. Permanent positions	45,916	46,930	48,135	48,236

The cost for permanent positions is the largest part of Personnel and Related Costs. The funds shown above will support 1,504 permanent positions in 1979, and 1,493 permanent positions in 1980.

Basis of Cost for Permanent Positions

The estimate for permanent compensation (starting from prior year cost) is based upon the position structure at the start of the year, as modified by the addition of new positions and abolishment of existing positions, within grade advances, career development, and the October 1978 pay raise. After these modifications, the year-end position structure is established and the cost effect for the year is calculated based on the estimated period that these modifications are in effect as follows:

Cost of permanent positions in 1979		48,135
Cost of increases in 1980		+1,220
Within grade advances and career development:		
Full year effect of 1979 actions	+391	
Partial year effect of 1980 actions	+414	
Full year effect of October 1978 pay raise	+44	
Two extra days	+371	
Cost decreases in 1980		-1,119
Turnover savings:		
Full year effect of 1979 actions	-677	
Partial year effect of 1980 actions	-442	
Cost of permanent positions in 1980		48,236

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
b. Nonpermanent positions				
1. Cost	906	1,175	1,205	1,203
2. Number of workyears	87	105	113	108

The increase in the 1979 current estimate over the budget estimate is due to the effect of the October 1978 pay raise, an increase in the disadvantaged youth programs and the implementation of an experimental part-time employment program. The change in 1980 reflects a continuation at the same level except for the absorption of the part-time program into the permanent position ceiling.

The 1980 plan includes 108 nonpermanent workyears, which will be used to support the following programs at the levels indicated below.

Distribution of Nonpermanent Workyears by Program

Program	Workyears
Cooperative program	12
Summer program	18
Youth opportunity program	41
Other temporary employment	37
Total	108

c. Reimbursable detailees	249	279	310	314

These funds provide for the services of military officers and civilians who are detailed from other Government agencies to NASA Headquarters where such assignments are of mutual benefit. The number detailed varies from seven to sixteen, all of whom are assigned to Headquarters program offices with the exception of three that are assigned to the Office of Facilities. The estimates for 1979 and 1980 will cover the cost of ten workyears. The 1979 current estimate and the 1980 estimate are increased from the 1979 budget estimate to reflect an increase of one workyear, as well as the cost of the October 1978 pay raise.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
d. Overtime and other compensation.....	255	277	342	343

The increase in the 1979 current estimate over the budget estimate reflects increased activity associated with key program milestones, especially the Shuttle program, and events within various management and operating offices, and the October 1978 pay raise. 1980 is essentially level with 1979.

2. Benefits.....	4,422	4,553	4,658	4,691

In addition to compensation, NASA makes an employer's contribution to personnel benefits as authorized and required by law. The increase in the 1979 current estimate and 1980 budget estimate from the 1979 budget estimate reflects the cost of the October 1978 pay raise partially offset by the savings due to the manpower reductions. The following table indicates the costs of personnel benefits by the various cost categories:

Category of Cost				
Civil Service Retirement Fund.....	3,217	3,291	3,378	3,365
Employee life insurance.....	197	215	212	217
Employee health insurance.....	718	726	730	733
Workmen's compensation.....	125	129	90	128
FICA.....	47	69	68	68
Incentive awards.....	97	90	145	145
Severance pay.....	21	33	35	35
Total.....	4,422	4,553	4,658	4,691
B. Supporting Costs.....	780	1,103	1,118	1,106

Supporting personnel costs provide for the expenses of moving employees to their initial duty station or reassignment; for security investigations and other recruitment costs; and for maintaining and expanding the skills of our employees. These costs are summarized as follows:

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
1. Transfer of personnel.....	163	220	220	234

Legislation enacted in 1966 provided that the Government would pay for certain relocation costs which are budgeted in this category, such as the expenses of selling and buying a home and the cost of family relocations. The estimated costs for 1979 and 1980 are based on the number and historical average cost of relocations.

2. Office of Personnel Management services.....	78	138	138	140

Headquarters reimburses the Office of Personnel Management and others for investigation of new hires and Equal Employment Opportunity complaints for the entire agency. The cost of investigation is a function of two variables, the number of investigations to be conducted, and the unit charge made by the Office of Personnel Management or other agencies. There is also a payment to the Commission for Federal wage system surveys and any requested investigation of formal discrimination complaints.

3. Personnel training.....	539	745	760	732

The maintenance and expansion of the skills is essential in carrying out the agency's many complex technical programs. Such training is provided within the framework of the Government Employees Training Act of 1958. Part of the training consists of courses offered by other Government agencies, usually for a fee. The remainder of the training is provided through nongovernmental sources. The costs are for tuition, fees, and related costs for training at colleges, universities, technical institutions, and for the cost of seminars and workshops in which groups of Headquarters and Field Center employees receive training in subjects of agencywide interest. Such training is used to maintain and expand employees skills. The 1980 estimate is $28,000 less than the 1979 current estimate due to a decrease in agencywide training and attendance at the Federal Executive Institute.

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TRAVEL

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
II. TRAVEL	2,385	2,545	2,494	2,697
Basis of Fund Requirements				
A. Program Travel	906	1,095	1,095	1,201
B. Scientific and Technical Meeting Travel	266	235	235	305
C. Management and Operations Travel	1,213	1,215	1,164	1,191
Total, Travel	2,385	2,545	2,494	2,697

A. Program Travel — 906 | 1,095 | 1,095 | 1,201

Program travel funds are used in support of NASA's research and development programs, such as the Space Shuttle, Aeronautics, Space and Terrestrial Applications, and other direct Research and Development (R&D) projects. This category represents approximately 45% of the Headquarters travel requirements for 1980. The increase in travel is due principally to the increased number of trips planned for 1980.

B. Scientific and Technical Meeting Travel — 266 | 235 | 235 | 305

Scientific and technical meeting travel permits employees to participate in meetings and seminars with other representatives of the aerospace community. This participation allows personnel to benefit from exposure to technological advances in the field which arise outside NASA, as well as to present both accomplishments and problems to their associates. Many of these meetings are working panels convened to solve certain problems for the benefit of the Government. The increase in 1980 is an attempt to restore the Headquarters scientific and technical meeting travel to a level in line with the 1978 level after adjustment for increases in transportation costs.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
C. Management and Operations Travel	1,213	1,215	1,164	1,191

Management and operations travel is for the direction and coordination of general management matters. It includes travel by senior officials to review Center requirements and operations, travel in such areas as personnel, financial management, and procurement to assure agency policies and procedures are being implemented properly throughout the agency; local transportation; and Congressional travel.

FACILITIES SERVICES

NASA Headquarters involves a complex of buildings in the District of Columbia and nearby Maryland and Virginia. These are either Government-owned or leased buildings for which NASA must provide reimbursement to GSA in accordance with P.L. 92-313.

This complex encompasses some 556,790 gross square feet of building space including six buildings. This complex of primarily office space supports an average daily Headquarters population of 2,000 to 2,100 personnel. The personnel are engaged in a one-shift operation exercising management over the centers that constitute the National Aeronautics and Space Administration.

III. FACILITIES SERVICES	4,988	5,610	5,576	5,662
Basis of Fund Requirements				
A. Rental of Real Property	4,454	4,777	4,768	4,866
B. Maintenance and Related Services				
1. Facilities	411	669	644	629
2. Equipment	---	10	---	---
Subtotal	411	679	644	629
C. Custodial Services	123	154	164	167
Total, Facilities Services	4,988	5,610	5,576	5,662

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
A. Rental of Real Property	4,454	4,777	4,768	4,866

This provides space for personnel as well as storage and warehouse space for equipment, supplies and materials. The requirements are approximately the same as those rented in 1979, however, the 1980 total cost increase reflects increased rental rates as projected by GSA.

B. Maintenance and Related Services	411	679	644	629
1. Facilities	411	669	644	629

This estimate includes funds for maintenance and alterations such as partition changes, telephone changes and general buildings maintenance. The 1979 budget estimate included $25,000 for medical equipment maintenance that has been realigned to the Management and Operations function in the 1979 current and 1980 budget estimates.

2. Equipment	---	10	---	---

This category in the 1979 budget estimate included funds for the maintenance and repair of security alarm systems. The budget has since been realigned and this item is now contained in Custodial Services below.

C. Custodial Services	123	154	164	167
1. Security guard service	119	154	154	157

These funds cover security guard service in the Headquarters buildings.

2. Security Alarm Systems	4	---	10	10

This estimate includes reimbursement to GSA for the installation and maintenance of the security alarm systems and equipment in the NASA Headquarters buildings.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
	(Thousands of Dollars)			
IV. TECHNICAL SERVICES	15,195	15,082	15,289	15,989
Basis of Fund Requirements				
A. Automatic Data Processing				
1. Equipment	1,608	1,800	1,279	1,298
2. Operations	3,042	3,962	3,597	3,752
Subtotal	4,650	5,762	4,876	5,050
B. Scientific and Technical Information				
1. Library	86	115	181	184
2. Educational and information	10,005	9,017	9,779	10,295
Subtotal	10,091	9,132	9,960	10,479
C. Shop Support and Services	454	188	453	460
Total, Technical Services	15,195	15,082	15,289	15,989
A. Automatic Data Processing	4,650	5,762	4,876	5,050

The funding provides for the lease, purchase, maintenance, programming and operations services of ADP equipment.

1. Equipment	1,608	1,800	1,279	1,298

The funding provides for the maintenance and lease of ADP equipment.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		

The reduction from the 1979 budget estimate to the 1979 current estimate is due to a decrease in rental of accessories and maintenance and repair of ADP equipment in the amount of $250,000. The remaining $271,000 is due to a realignment of requirements from the ADP function to scientific and technical information.

2. Operations	3,042	3,962	3,597	3,752

This funding provides for the programming and operation services for payroll, accounting, procurement, personnel, and contracts reports. The decrease in operations in the 1979 current estimate from the budget estimate is due to a reduction in the time sharing service partially offset by an increase in support contractor manpower at higher wage rates than originally budgeted. The increase in the 1980 estimate is due primarily to requirements for mass storage, replacement copiers and microfiche developer.

B. Scientific and Technical Information	10,091	9,132	9,960	10,479
1. Libraries	86	115	181	184

The technical libraries provide reference acquisition, cataloging, translating and dissemination services to all NASA employees. The increase in the 1979 current estimate from the 1979 budget estimate is due to realigning the costs for the operation of the NASA Headquarters library to the education and information function.

2. Education and Information	10,005	9,017	9,779	10,295

Two major activities are contained in this subfunction. The first is education and information programs and the second is the NASA Headquarters scientific and technical information activity. The increase in the 1979 current estimate over the 1979 budget estimate is due to the realignment of some of the requirements of the NASA Scientific and Technical Information Facility (STIF) from the ADP function. The increase in 1980 is due to support contractor wage increases.

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
a. Education and information programs				2,557

The educational and informational programs provide for the gathering and dissemination of information about the agency's programs to the mass communications media, the general public, and to the educational community at the elementary and secondary levels. Assistance to the mass communications media includes the gathering and exposition of newsworthy material in support of their requests, and takes such forms as press kits, news releases, television and radio information tapes and clips, and feature material. Research, development, and operational missions in aeronautics and space provide substantive knowledge and serve as an educational stimulus to students and teachers. NASA responds to expressed needs of students by developing curriculum supplements in space-related areas such as physics, biology, chemistry, and math; assistance to over 1,000 teacher workshops and professional education meetings (with over 30,000 teachers participating); and participation in science fairs. The largest single program is the Aerospace Education Science program, a touring space science education lecture demonstration unit. This program also provides for Equal Employment Opportunity exhibits and films to relate to high schools, colleges and the public, the key roles that women and minorities have in the U.S. Space Program.

b. Scientific and technical information				7,738

The scientific and technical information activity includes the cost of the NASA Scientific and Technical Information Facility (STIF), documentation and publication services, systems development, and translation services. The largest requirement is the NASA Scientific and Technical Information Facility, which is estimated to cost $3.8 million in 1980. The cost of all other information services is estimated at approximately $3.9 million in 1980. These costs are for the documentation of worldwide aerospace journal and report literature; monographs and technical reviews; analyzing, evaluating, and testing new methods and systems in the field of scientific communications to increase the effectiveness of the technical information program; and translating foreign language technical books, reports, and journal articles required to meet the needs of NASA and its contractor scientific personnel to keep abreast of world developments in the space science and related fields.

C. Shop Support and Services	454	188	453	460

These funds provide for the continuation of studies on reliability cost evaluations and NASA-wide Safety, Reliability and Quality Assurance Standards. Also included here are Graphic and Photo Processing

Services. The change from the 1979 budget estimate to the 1979 current estimate is a result of moving Graphic and Photo Processing Services from the Installation Common Services function to Shop Support and Services. There is no change in the level of effort of this program for 1980.

MANAGEMENT AND OPERATIONS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
V. MANAGEMENT AND OPERATIONS	6,029	6,978	6,919	7,256
Basis of Fund Requirements				
A. Administrative Communications	1,214	2,284	1,497	1,520
B. Printing and Reproduction	1,043	722	1,108	1,124
C. Transportation	374	182	299	304
D. Installation Common Services	3,398	3,790	4,015	4,308
Total, Management and Operations	6,029	6,978	6,919	7,256
A. Administrative Communications	1,214	2,284	1,497	1,520

Provides for the costs of leased lines, long distance tolls, telephone exchange services, and other communications. The decrease in the 1979 current estimate from the 1979 budget is due primarily to the postage costs which are now reported under the Installation Common Services function.

1. Local telephone service 556

Includes cost of operation of telephone exchange services.

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	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
2. Long distance telephone service				794
Covers cost of leased lines and long distance tolls.				
3. Nontelephone communications (Includes TXW) services				170
B. Printing and Reproduction	1,043	722	1,108	1,124

Administrative printing includes contractual printing and related composition and binding operations. This includes services performed by other agencies, chiefly the Government Printing Office (GPO), and by commercial printing firms. All common processes of duplicating including photostating, blueprinting, microfilming and other reproductions, are included. The increase in the 1979 current estimate over the budget estimate is due primarily to reimbursing the GPO for the Agency's share of printing cost for the Federal Register and the Code of Federal Regulations.

C. Transportation	374	182	299	304

Includes rental of trucks, as well as the movement of supplies, materials, equipment and related items. Also included is the cost of operating and maintaining the administrative aircraft which is assigned to the Jet Propulsion Laboratory but funded through NASA Headquarters. The increase in the 1979 current estimate from the budget estimate is due to two major items: purchase of motor vehicles for the Jet Propulsion Laboratory; and increased costs for the operation and maintenance of the Beachcraft Queenaire administrative aircraft.

D. Installation Common Services	3,398	3,790	4,015	4,308

This function includes those services which support the Headquarters generally, such as: patent services; maintenance and repair of office equipment and vehicles; minor Government services; contract histories; trucking and laboring services; medical services; international support services; contractor incentive awards; Equal Employment Opportunity community relations and fellowships; Administrator's

	1979		1980
1978 Actual	Budget Estimate	Current Estimate	Budget Estimate
	(Thousands of Dollars)		

representation allowance; NASA management training facility study; overseas administration support and documentation; and administrative supplies, materials and equipment. The increase in the 1979 current estimate over the budget estimate is due to the postage being categorized into the installation common services function from the communications function. This is partially offset by graphics and photo processing services being moved into the shop support and services function under Technical Services and the photocopy equipment operation moving to the printing and reproduction service. The level of services being provided is constant in 1979 and 1980.

1. Installation support services..... 2,076

Included in this category, specifically, are such services as Administrator's representation allowance, contract histories, minor Government services, labor and traveling services, overseas support, contractor incentive awards, Headquarters Equal Employment Opportunity community relations and fellowships, patent fees and services, and Aerospace Fellowships.

2. Medical services..... 381

This funding provides for the services and required supplies of the medical health unit and includes the cost of the staff examinations support service contract.

3. Supplies, materials and equipment..... 1,851

This funding provides for the purchase and rental of office equipment and the supplies and materials required for the operation of NASA Headquarters.

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ORGANIZATION AND STAFFING

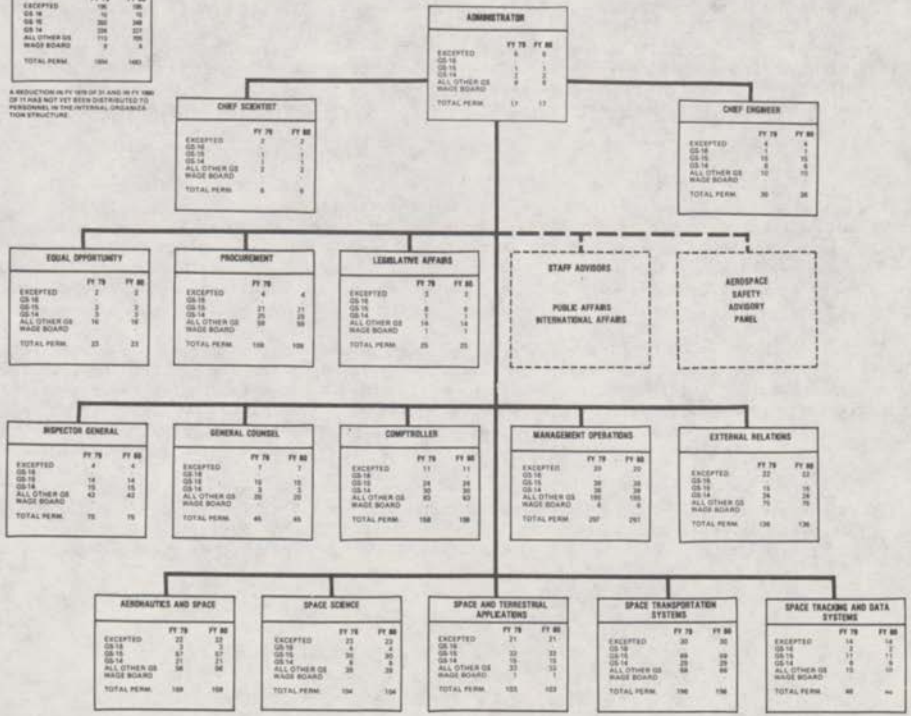
NASA HEADQUARTERS

HEADQUARTERS

SUMMARY STAFFING

	FY 79	FY 80
EXCEPTED	196	195
GS-16	10	10
GS-15	350	349
GS-14	226	227
ALL OTHER GS	113	105
WAGE BOARD	9	9
TOTAL PERM.	1904	1903

A REDUCTION IN FY 1979 OF 31 AND IN FY 1980 OF 71 HAS NOT YET BEEN DISTRIBUTED TO PERSONNEL IN THE INTERNAL ORGANIZATION STRUCTURE.



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RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1980 ESTIMATES

JET PROPULSION LABORATORY

DESCRIPTION

The Jet Propulsion Laboratory (JPL) is located in Pasadena, California, approximately 20 miles north of downtown Los Angeles. Subsidiary facilities are located at Goldstone, California, (tracking and data acquisition), Edwards Air Force Base, California (propellant formulation and testing), and Table Mountain, California (open air testing and astronomy).

At Pasadena, The Laboratory occupies 176.8 acres of land of which 155.0 acres are owned by NASA and 30.9 acres are leased. At Goldstone, facilities are located on land occupied under permit from the Army. At Edwards Air Force Base, facilities are located on land occupied under permit from the Air Force. Facilities at Table Mountain are located on land occupied under permit from the Forest Service of the Department of Agriculture. The capital investment of the Jet Propulsion Laboratory, including the Deep Space Network, fixed assets in progress, and contractor-held facilities, as of June 30, 1978, was $414,154,000.

The Jet Propulsion Laboratory is a Government-owned facility, managed, staffed, and operated by the California Institute of Technology under a contract with NASA. The entire cost of operating the Laboratory is borne by the Research and Development appropriation, except for the lease or purchase of administrative aircraft and the purchase of passenger motor vehicles, which costs are funded from the Research and Program Management appropriation and are included in the NASA Headquarters budget presentation. Accordingly, the Research and Program Management type costs presented in this Special Analysis for JPL are for purposes of comparison only, and are not a part of the NASA Research and Program Management budget.

MISSION

The Jet Propulsion Laboratory has been assigned primary responsibility for the conduct of NASA programs concerned with scientific exploration of the planets and interplanetary space using automated spacecraft. The Laboratory is also assigned the conduct of selected automated earth-orbital missions. Implicit in these assignments is a broad range of engineering, scientific, and management functions devoted to:

1. The conduct of complete spaceflight projects, including overall project management and all phases of project activity beginning with mission design and scientific justification and following with spacecraft design, development, testing, and flight operations.

2. The development and operation of the Deep Space Network which provides tracking and data acquisition services for all NASA projects involving flights of automated spacecraft beyond near-earth orbits.

3. Continuing programs of scientific investigation and supporting research and technology.

In more specific terms, Laboratory activities in support of NASA can be categorized as follows:

Planetary Exploration - Since the very beginning of the Nation's space activities, the Jet Propulsion Laboratory has devoted a major part of its effort to the Planetary Exploration Program. The Mariner series of spacecraft was designed and developed by JPL, and the Laboratory has had project management responsibility for all Mariner missions, including the functions of integration, assembly, and testing of the spacecraft. The most recently completed missions in the Mariner series are those of Mariner 9, which returned scientific data for nearly a year from an orbit around Mars; and Mariner 10, which gathered data in a close flyby of Venus followed by three separate encounters with Mercury. Similar to the Mariner spacecraft, the Viking Orbiters, launched with the Viking Landers in 1976, have performed successfully and are planned to operate to Spring 1979.

In the continuing series of planetary missions, the Jet Propulsion Laboratory has management responsibility for the Voyager Jupiter-Saturn mission. Two spacecraft have been launched, on August 20 and September 5, 1977, and are currently operating well in cruise mode on planned trajectories. The launches occurred as intended during a time period when the relative positions of Jupiter and Saturn were uniquely favorable for the utilization of gravity-assist techniques to shorten flight times to Saturn. Voyager encounters at Jupiter will occur in March and July of 1979, and at Saturn in November 1980 and August 1981. Scientific data will be gathered on the interplanetary medium, the planets themselves, several of their large satellites, and the rings of Saturn. The mission design includes an option to adjust the trajectory of one spacecraft as it nears Saturn and enable it to continue on to Uranus. The spacecraft for these missions make maximum use of previous Mariner and Viking Orbiter designs and technology, consistent with the requirements of long-range communications, solar independent power, and the required flight times.

The Jet Propulsion Laboratory also has project management responsibility for the Galileo mission, which was a new project start in 1978. This mission is designed to orbit the planet Jupiter and send an instrumented probe into the planet's atmosphere. The atmospheric probe will make direct measurements of physical and chemical properties and will be designed to survive to a considerable depth. The orbiter will have a lifetime in orbit of about 20 months during which it will observe Jupiter and several of its major satellites at close range. Galileo will be the first planetary mission to be launched aboard the Space Shuttle. The launch data is scheduled for January 1982. Jupiter encounter will occur in June 1985.

The International Solar Polar Mission (ISPM) is also managed at JPL. JPL has mission management responsibility as well as responsibility for the U.S. spacecraft and science. The European Space Agency (ESA) has the

responsibility for the European spacecraft and European science. The dual launch of the spacecraft will be in 1983 and the spacecraft flight will use the Jovian gravitational effect to propel the two spacecraft out of the solar equatorial plane in order to provide a new and unique science opportunity for solar observation.

Scientific Satellites - Consistent with its role as an alternate center for earth-orbital spacecraft development, the Laboratory has been selected to manage the Infrared Astronomy Satellite (IRAS) project. This project will involve international cooperation with the spacecraft bus being designed and built in the Netherlands. The NASA Ames Research Center will be responsible for the infrared telescope. Development activities are in progress, and launch is scheduled for the second quarter of 1981.

Supporting Research and Technology - The Jet Propulsion Laboratory maintains a strong program of supporting research and advanced technical development designed to provide sound technologies for present and prospective project assignments, and to further the general capabilities of NASA. Areas of involvement include spacecraft advanced development, autonomous systems, space power and electric propulsion, chemical propulsion, electronics, and basic research in such fields as fluid physics, polymer materials, and applied mathematics.

Science Program - The Laboratory participates in scientific experiments on both JPL-managed and non-JPL managed flight projects. This participation includes not only the performance of scientific investigations, but also a significant commitment to the development of scientific instruments for use in space missions. Ground-based research programs are carried out in the planetary sciences, physics and astronomy, and earth and ocean physics. These activities involve broad collaboration with the scientific and academic communities and with staff members from other NASA field installations.

Tracking and Data Acquisition - The Jet Propulsion Laboratory is responsible for the design, development, maintenance, and operation of NASA's worldwide Deep Space Network and a Mission Control and Computing Center. Tracking stations are located in California, Spain, and Australia. These facilities provide support not only to JPL-managed flight missions, but also to projects such as Pioneer and Helios managed by other NASA installations and involving flights beyond near-earth orbits.

Distribution of Permanent Positions by Program

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Direct Positions				
Space Transportation Systems	7	6	---	---
Space Shuttle	4	4	---	---
Space flight operations	3	2	---	---

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
Space Science	892	972	1,105	1,104
Physics and astronomy	116	76	120	99
Planetary exploration	757	874	966	986
Life sciences	19	22	19	19
Space and Terrestrial Applications	212	153	190	171
Space applications	199	148	173	157
Technology utilization	13	5	17	14
Aeronautics and Space Technology	294	302	272	261
Aeronautical research and technology	17	15	15	15
Space research and technology	248	257	237	230
Energy technology	29	30	20	16
Space Tracking and Data Systems	379	413	385	391
Tracking and data acquisition	379	413	385	391
Subtotal, direct positions	1,784	1,846	1,952	1,927
Direct Support	570	581	636	620
Center Management and Operations Support	1,043	1,045	1,156	1,151
Total, permanent positions	3,397	3,472	3,744	3,698

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Thousands of Dollars)		
I. Personnel and Related Costs	96,586	101,148	114,042	113,934
II. Travel	3,787	4,187	3,824	3,800
III. Facilities Services	8,703	9,371	10,075	10,577
IV. Technical Services	2,556	3,849	2,754	2,966
V. Management and Operations	5,551	10,960	5,970	6,181
Total, fund requirement	117,183	129,515	136,665	137,458

SIMULATED RESEARCH AND PROGRAM MANAGEMENT BUDGET

EXPLANATION OF CHANGES

Personnel and Related Costs - The increase from 1979 budget to the current estimate is attributable to (1) higher starting salaries resulting from merit increases in 1978, (2) a higher manpower estimate for 1979, and (3) the resulting increase in cost of benefits due to additional manyears and higher rate and base for calculating FICA. The decrease from 1979 to 1980 is due to the reduction of positions planned in 1980.

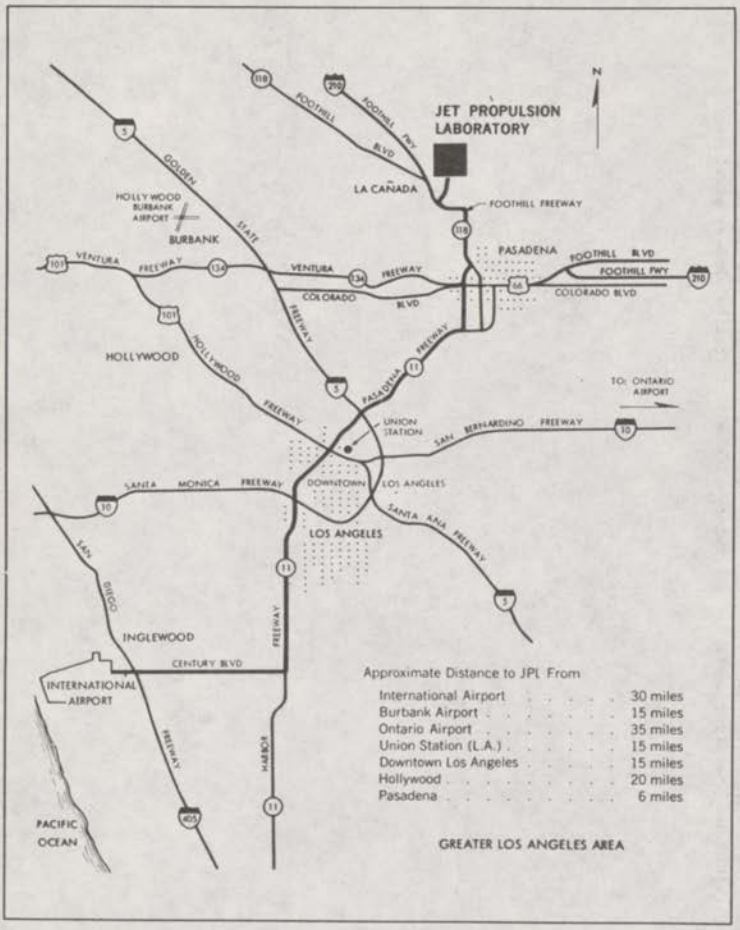
Travel - Travel is remaining at approximately the same level in 1980 as in 1979.

Facilities Services - The increase from 1979 budget to the current estimate results from updated estimates for maintenance alteration and repair (+$373,000) and for operation of facilities, including utilities (+$284,000). The increase from 1979 to 1980 is due to higher costs of maintenance and repair, as well as higher costs for electricity (+$342,000) and gas (+$51,000).

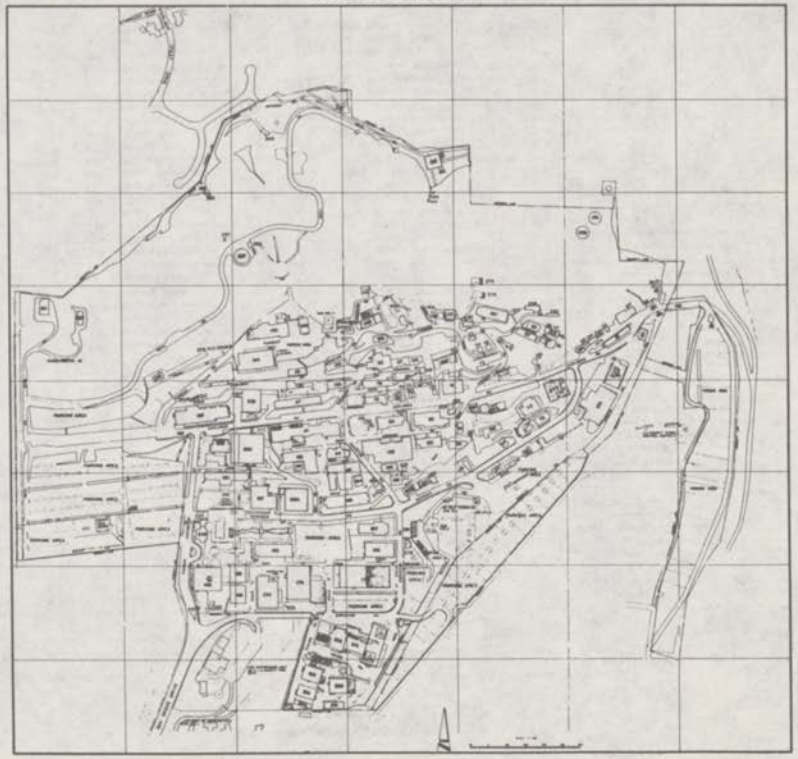
Technical Services - The increase from 1979 to 1980 is due to a higher demand for these services, principally technical documentation, library support and fabrication.

Management and Operations - The decrease from 1979 budget to current estimate results from removing the Caltech fee and overhead from the simulated R&PM account. The increase from 1979 to 1980 is due to increased rates for communication services and increased costs for laboratory-wide administrative support services.

JET PROPULSION LABORATORY



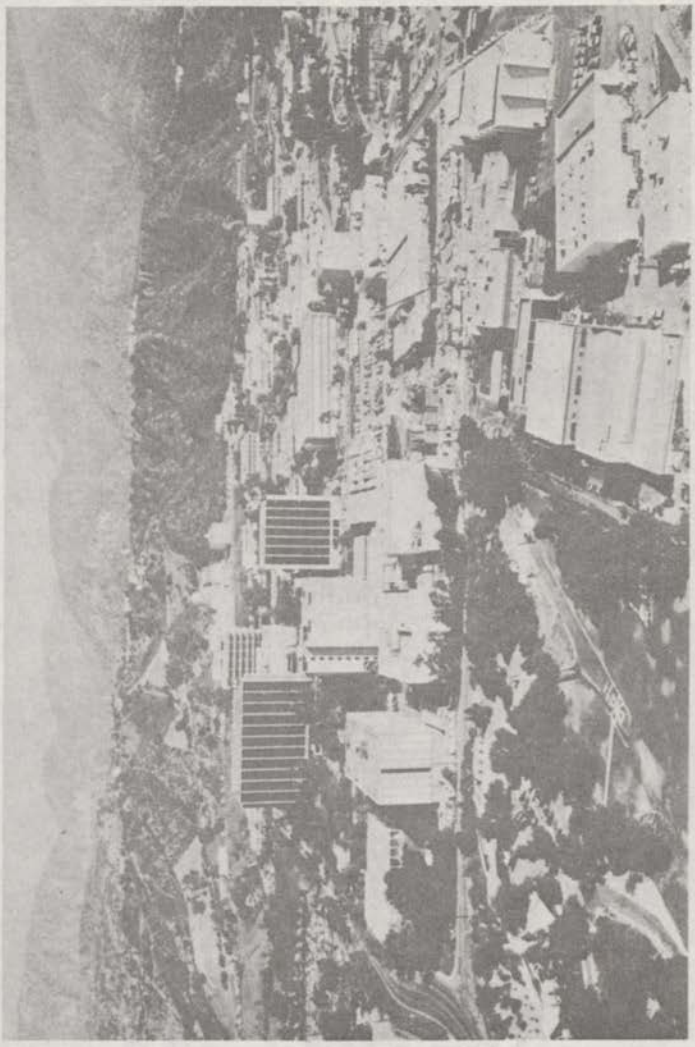
JET PROPULSION LABORATORY
FISCAL YEAR ESTIMATES
LOCATION PLAN



SA 8

JET PROPULSION LABORATORY
LEGEND

Bldg. No.	Title	Location
11	Space Sciences Lab	E-2
13	Offices, Lab & Shop	D-3
18	Structural Test Lab	D-2
20	Shop Test Cell No. 2 (Liq)	D-2
21	Shop Test Cell No. 12 (Liq)	E-2
31	Test Cell (Liq)	E-2
32	Test Cell (Liq)	D-2
33	Test Cell (Liq)	D-3
34	Shop Test Cell No. 33 (Liq)	D-3
35	Mag Flux Tank Shelter	B-1
41	Hi-Temp Lab	D-3
42	Test Cell (Liq)	D-3
46	Shop Test Cell No. 42 (Liq)	D-3
47	Plant Protection	D-2
53	Conditioning Lab (Solid)	D-3
54	Blending Lab (Solid)	D-2
55	Mixing Lab (Solid)	D-2
57	Test Cell (Air Fuel)	C-2
58	Compressor Bldg	C-2
59	Chemistry Lab	D-3
65	Materials Lab	D-3
67	Microbiology Facility	B-2
71	Mechanics Stores	D-2
72	Engineering Offices	C-2
73	Utilities Area Storage	D-3
74	Test Cell (Chemistry)	D-3
77	Soil Science Lab	C-2
78	Hydraulics Lab	D-3
79	Wind Tunnel (20 inch)	C-2
80	Wind Tunnel (21 inch)	C-2
81	Battery Laboratory	E-2
82	Environmental Test Lab	C-2
83	Electronic Parts & Engineering	C-2
84	Test Cell & Solid Chemistry	D-2
85	Business Systems Office	C-2
86	Oxidizer Grinding (Solid)	D-2
87	Ovens (Solid)	D-2
88	Mixing Lab (Solid)	D-2
89	Processing Lab (Solid)	D-2
90	Shop Test Cell No. 51	D-2
91	Air Dryer (Wind Tunnel)	C-2
92	Cooling Tower (Wind Tunnel)	C-2
93	Vaporizer (Wind Tunnel)	C-2
97	Development Lab & Offices	D-2
98	Preparation Shop (Solid)	D-2
99	Chemistry Lab (Solid)	D-3
103	Fabrication Shop	E-3
106	Test Cell (Air Fuel)	C-2
107	Test Cell	E-2
109	Cooling Tower (Wind Tunnel)	C-2
110	Fuel Stor Tank	C-2
111	General Offices Bldg	B-2
114	Cafeteria & Offices	C-3
115	Heating Plant (Solid)	D-2
116	Propellant Storage Dock	D-2
117	Test Cell (Solid)	D-2
118	Cooling Tower	C-3
120	Cooling Tower	D-2
121	Employment Development Ctr	E-2
122	Engineering Offices	C-3
125	Combined Electronics	C-3
126	Systems Div Office Bldg	B-2
129	Test Cell (Chemistry)	D-3
130	Engineering Offices	C-2
133	Service Dock	C-2
134	Shop Test Cell	E-2
135	Guard Shelter	A-2
136	Cooling Tower	C-2
137	Cooling Tower	C-2
138	Engineering Offices	C-2
140	Magazine X Temp	C-2
141	Magazine X Temp	C-2
145	Magazine Propellant	D-2
147	Cooling Tower	D-2
148	Energy Conversion Lab	C-2
150	25-ft Space Simulator	B-2
152	Hazardous Chemical Stor	C-3
156	Computer Program Office	B-3
157	Engineering & Mechanics Bldg	C-3
158	Material Research Proc Lab	C-3
159	Pump House (Water)	E-2
160	Sewage Lift Station	C-3
161	Telecommunications Lab	C-3
165	Cooling Tower	C-3
166	Cooling Tower	C-2
167	Cafeteria	B-3
168	Space Sciences Instmt's Sys Lab	B-3
169	Engineering Office Bldg	B-3
170	Fabrication Shop	C-3
171	Materials Service Bldg	C-4
173	Test Shelter	E-2
174	Cooling Tower	C-2
175	Water Reservoir	E-2
177	Transportation Garage	D-2
179	Spacecraft Assy Facility	B-3
180	Central Engineering Bldg	B-3
182	Bus Stop Shelter	E-2
183	Physical Science Lab	B-3
184	Electronic Stores	C-3
185	Programming Office	B-3
186	Space Sciences Div Bldg	A-3
187	Chemical Storage	D-3
188	Engineering Facilities Bldg	C-2
189	Electronics Lab - Annex	C-3
190	190A - Procurement Offices	B-4
191	Hazardous Test Bay	E-2
192	Propulsion Engineering	D-3
195	Guard Shelter	B-3
196	Guard Shelter	B-2
197	Solid-Propellant Process Lab	D-2
198	Guidance Lab	C-3
199	Celestial Simulator Bldg	C-3
200	Plant Engineering Services	B-4
201	Carpenter Shop	B-4
202	Procurement Offices	B-4
209	Illuminator Tower	D-1
210	Blaine Truck	D-1
212	Antenna Lab	D-1
213	Cooling Tower 'A', 'B' & 'C'	B-2
218	Credit Union	B-3
220	C.R.S. Terminal Bldg	C-2
224	Sewer Lift Station	B-4
225	Guard Shelter - Mesa	C-1
226	Solvent Storage Bldg	C-2
227	Guard Shelter	B-1
228	Cooling Tower (A & B)	B-2
229	Shielded Room Bldg	C-3
230	Space Flight Operations Facility	B-2
231	Paint Shop	B-4
233	Spacecraft Development Bldg	B-3
234	Lumber Stor Bldg	B-4
237	Cooling Tower	D-2
238	Telecommunications Lab	B-2
239	Low-Temp Solid Prop Mag	D-2
241	Shipping & Receiving	B-4
243	Remote Antenna Range Contr	B-1
244	Hi-Temp Stor Mag	D-2
245	Spectroscopy Lab	B-2
246	Soils Test Lab	C-2
248	10-ft Space Simulator	C-2
249	Visitor Reception Bldg	B-2
250	Guard Shelter	B-2
251	Gyro Lab	A-2
253	Low-Mag Interference Lab	A-2
255	Sewage Lift Station	B-2
256	Model Range Control Bldg	A-1
257	Guard Island	B-2
258	Water Reservoir	E-2
259	Liquid Nitrogen Bottling Stor	D-2
260	Illuminator Equipment Bldg	B-1
261	Material Storage	C-3
262	Radiometer Bldg	B-1
263	Protective Services Bldg	C-3
264	SFOF Sys Dev Lab	B-3
267	Water Reservoir	B-2
268	Pump House	B-1
269	Grounds Maintenance Bldg	C-4
270	Sewage Metering Station	A-3
271	Oil Barrel Stor	C-3
272	East Illuminator Bldg	C-1
273	East Illuminator Tower	C-1
274	Cooling Tower	C-3
275	Chemical Stor Prop Bldg	D-2
276	Chemical Stor Prop Bldg	D-2
277	Isotope Thermoelectric Lab	D-2
278	Helicopter Maint Hangar	C-3
279	Guard Island	B-3
280	Static Test Tower	D-2
281	Fireman / Guard Station	C-3
283	Metal Storage Building	C-3
284	Transportation Office Bldg	D-2
285	Arroyo Bridge	E-2
286	Guard Bldg Arroyo	E-2
287	Island Guard Bldg	E-2
288	Project Equipment Storage	C-2
	'A' Gate	A-2
	'B' Gate	A-3
	'C' Gate	B-2
	'D' Gate	E-2
	'E' Gate	B-2
	'F' Gate	B-2
	'G' Gate	A-2



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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1980 ESTIMATES

SUMMARY OF AERONAUTICAL RESEARCH AND TECHNOLOGY
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

	1978 Actual	1979 Budget Estimate	1979 Current Estimate	1980 Budget Estimate
		(Millions of Dollars)		
Research and development	228.0	264.1	264.1	300.3
Construction of facilities	38.4	76.5	76.5	62.5
Research and program management	170.7	181.2	189.2	194.1
Total	437.1	521.8	529.8	556.9
Number of direct positions (end of year) associated with aeronautical research and technology	3,887	3,925	3,896	3,921

The objectives of the Aeronautical Research and Technology program are to provide the Nation with the necessary technology for safer, more economical, more efficient, and environmentally acceptable air transportation to maintain a strong U.S. competitive position in the international aviation marketplace; and to support the Department of Defense in maintaining the superiority of U.S. military aircraft.

The 1980 program supports these objectives by stressing the technology areas judged to be the most critical by special assessments, advisory groups, and by industry and other users of technology within and outside the Federal Government. The 1980 activities are designed to maintain a strong research and technology base position in the various technology disciplines. The strength of this generic research and technology base is essential to enhance the growth of new improved aeronautical products. Emphasis will be placed on improving aircraft energy efficiency and performance; reducing noise and pollution; and improving safety in terminal area operations.

In the area of conventional takeoff and landing aircraft, efforts on technology to reduce aircraft noise and emissions, to improve terminal area safety and aircraft operations, and to evaluate the suitability of broad specification jet fuels for use in current and future commercial jet engines will continue. Major emphasis will be on aircraft energy efficiency technology efforts, including the testing of individual components to validate the technology for use in high-bypass turbofan engines as part of the energy efficient engine program.

Rotorcraft activities will continue to address rotor aerodynamics, structures, avionics, flight dynamics, terminal operations, engines and drive systems and rotor system design. General aviation activities will emphasize the reduction of noise and emissions, crashworthiness and advanced low-cost avionics systems. In vertical takeoff and landing technology, broad based technology for future military and civil aircraft applications will be continued. Supersonic cruise research will place emphasis on the interactions between the airframe and propulsion system, long-life structural tests, and demonstration of advanced propulsion components. Also, efforts in the area of high performance aircraft will continue on configuration aerodynamics and flight testing of highly maneuverable aircraft technology concepts.

The construction of facilities request for 1980 includes the completion of the funding for the construction of the National Transonic Facility at the Langley Research Center and for the modification of the 40x80-Foot Subsonic Wind Tunnel at the Ames Research Center. It also provides for the first part of the modification to the Central Air System, the system that provides air to the test cells and large propulsion cells at the Lewis Research Center; modification of the 8-Foot Transonic Pressure Tunnel to do laminar flow research at Langley Research Center; modification of the Model Support System of the 8-Foot High Temperature Structures Tunnel at the Langley Research Center; and modification to the Static Test Facility at the Ames Research Center.

The research and program management funding provides for the civil service salaries, travel, electric power for wind tunnel operations, and other general installation costs necessary to conduct the aeronautics program.

RESEARCH AND DEVELOPMENT

ESTIMATED FY 1980 OBLIGATIONS FOR
EQUIPMENT TO BE PLACED AT NASA INSTALLATIONS

Program Budget Line Item	1980 (Thousands of Dollars)
Space Transportation Systems	72,305
Space Shuttle	(36,879)
Space Flight Operations	(35,397)
Expendable Launch Vehicles	(29)
Space Science	5,150
Physics and Astronomy	(1,097)
Planetary Exploration	(22)
Life Sciences	(4,031)
Space and Terrestrial Applications	13,152
Aeronautics and Space Technology	32,911
Aeronautical Research and Technology	(23,043)
Space Research and Technology	(8,142)
Energy Technology	(1,726)
Tracking and Data Acquisition	11,770
GRAND TOTAL	135,288

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1980 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1980 OBLIGATIONS ($ IN THOUS.)	RELATED FACILITY PROJECT
Space Shuttle	Johnson Space Center Bldg. 35, 72-76-01	Shuttle Procedures Simulator	Provides shuttle crew station procedures simulator	100	
Space Shuttle	Johnson Space Center Bldg. 5, 72-76-03	Shuttle Mission Simulator	Provides both a motion base and fixed simulator with out-the-window display	2400	FY 1976 Modifications to Crew Training Facilities Bldg. 5 C o F Project 7278
Space Shuttle	Johnson Space Center Bldg. 30, 72-77-01	Computers for Shuttle Data Processing Complex	Replacement of computers in real time computer complex	1456	FY 1977 Modifications to the Mission Control Center Bldg.30
Space Shuttle	Johnson Space Center Bldg. 30, 72-77-03	Analog Event System	Accepts digital output data from other systems and converts to visual media for interpretation	150	
Space Shuttle	Johnson Space Center Bldg. 30, 72-78-03	Orbiter Data Reduction Complex	Computers to support post flight orbiter data reduction	900	FY 1978 Modifications to Administrative Bldg. 30
Space Shuttle	Johnson Space Center Bldg. 30, 72-80-01	On-board Television	Provides downlink Shuttle Video prior to release	150	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1980 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1980 OBLIGATIONS ($ IN THOUS.)	RELATED FACILITY PROJECT
Space Flight Operations	Johnson Space Center Bldg. 30, 72-78-08	Dump Data Facility	Handles and processes all data recorded on-board shuttle vehicles	247	
Space Flight Operations	Johnson Space Center Bldg. 30, 72-79-04	Flight Planning (System II)	Purchase of computer and peripherals for design and documentation of missions for the STS to a rate of 20 flights/year.	180	
Space Flight Operations	Johnson Space Center Bldg. 30, 72-79-05	Flight Planning System III	Purchase of computers and peripherals for design and documentation of missions with the intent of increasing the design capability to 60 flights/year	3000	
Space Flight Operations	Johnson Space Center Bldg. 30, 72-79-06	Hardcopy Unit	To provide hardcopy of Digital Data display from the SDPC	350	
Space Flight Operations	Johnson Space Center Bldg. 30, 72-79-07	Payload Operating Control Center (POCC) Decommutator	To provide the capability to process command and control parameters from several independent Payload data streams simultaneously	157	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1980 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1980 OBLIGATIONS ($ IN THOUS.)	RELATED FACILITY PROJECT
Space Flight Operations	Johnson Space Center Bldg. 30, 72-77-04	Network Interface Processor (NIP)	Provides interface between Mission Control Center and space tracking data network	500	
Space Flight Operations	Johnson Space Center Bldg. 30, 72-77-05	Master Interface Timing System	Provides central timing system for Mission Control Center (MCC)	200	
Space Flight Operations	Johnson Space Center Bldg. 30, 72-78-01	Wide Band Recorder	Records incoming data at Mission Control Center	500	
Space Flight Operations	Johnson Space Center Bldg. 30, 72-78-02	Display Control System	Provides data and control interface between the display control system and the shuttle data processing complex	546	
Space Flight Operations	Johnson Space Center Bldg. 30, 72-78-05	Digital Voice Unit	Unit for converting digital voice from on-board shuttle to its normal analog output and also converting analog to digital uplinks	400	
Space Flight Operations	Johnson Space Center Bldg. 5, 72-78-07	Spacelab Simulator (SLS)	Simulator to train flight and ground crews for the operation and monitering of spacelab subsystems	800	FY 1978 Modification to accommodate Spacelab Support Simulator Bldg. 5

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1980 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1980 OBLIGATIONS ($ IN THOUS.)	RELATED FACILITY PROJECT
Space Flight Operations	Johnson Space Center Bldg. 30, 72-79-08	Wide Band I/F Equipment	To provide capability to bring independent payload high rate data streams into JSC POCC	1342	
Space Flight Operations	Johnson Space Center Bldg. 30, 72-79-09	Payload Data Interleaver System	Downlink System to accept and process Digital Data from Shuttle PDI.	491	
Space Flight Operations	Johnson Space Center Bldg. 30, 72-79-10	Text and Graphics System	System to provide for uplink of Text and Graphics information to the Shuttle	610	
Space Flight Operations	Johnson Space Center Bldg. 5, 72-79-11	Interim Upper Stage Simulater (IUSS)	The IUSS will be a set of equipment which will provide the added capability to the Shuttle Mission Simulator to train the flight crews to monitor and control the Interim Upper Stage vehicle and its subsystems. It will essentially provide a visual scene of the IUS in the windows of the SMS and allow the simulation of vehicle dynamics within the SMS computer complex	185	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1980 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1980 OBLIGATIONS ($ IN THOUS.)	RELATED FACILITY PROJECT
Space Flight Operations	Johnson Space Center Bldg. 16, 72-80-02	Aeronautics Test Support System Quick Look Station	Supports spacecraft aeronautics verification testing	338	
Space Flight Operations	Johnson Space Center Bldg. 30, 72-80-03	Data Quality Monitoring and Testing Equipment	Insures that data received is of sufficient integrity prior to processing by the Mission Control Center (MCC)	529	
Space Flight Operations	Kennedy Space Center 76-78-10	Launch Processing System (LPS) for Shuttle Flow II	Supports the second line of facilities for processing two shuttle orbiters.	6200	
Space Flight Operations	Kennedy Space Center 76-78-11	Cargo Intergration Test Equipment (CITE)	Performs Orbiter/ Cargo interface verification prior to cargo installation	5238	
Space Shuttle Operations	Marshall Space Flight Center Bldg. 4487, 62-80-01	Replacement of EAI 80 Digital Portion of EAI 8900 Hybrid Computer	Perform Simulations of Shuttle assent with real winds; IUS and 25KW power module; and closure path; thrust impingement effects and grappling capability studies for Large Space Structures and Teleoperator Retrieval System	250	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1980 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1980 OBLIGATIONS ($ IN THOUS.)	RELATED FACILITY PROJECT
Aeronautical Research and Technology	Ames Research Center Bldg. 239, 21-80-01	External Scene Generation System	Provides realistic situatuion to the aircrew in order to promote the fidelity of their performance in the "full system" human factors research	700	
Aeronautical Research and Technology	Ames Research Center Bldg. N-233, 21-80-02	CDC-7600 Computer Disk Expansion	Provide expanded disk memory capability	300	
Aeronautical Research and Technology	Ames Research Center Bldg. 243, 21-80-03	FSAA Servo Drive System	Provide solid state electronics for the Motion Drive Servo Control System for the Flight Simulator for Advanced Aircraft (FSAA)	250	
Aeronautical Research and Technology	Ames Research Center Bldg. 243, 21-80-04	Analog Systems Replacements	Provide replacement analog computers for the simulation complex	475	

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1980 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1980 OBLIGATIONS ($ IN THOUS.)	RELATED FACILITY PROJECT
Aeronautical Research and Technology	Ames Research Center Bldg. 210, 21-80-05	Sigma 9 (Disk C)	Provide updated computer and related simulator interconnection equipment	450	
Aeronautical Research and Technology	Lewis Research Center 22-79-01	Scientific Computer	To provide increased computational speed, increased memory capacity, improved system reliability, and increased terminal support both for test facilities and interactive terminals	3200	Funding also supported by Space Research and Technology and other Programs. C o F Project 2271

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1980 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1980 OBLIGATIONS ($ IN THOUS.)	RELATED FACILITY PROJECT
Physics and Astronomy	Goddard Space Flight Center Bldg. 11, 51-79-02	Minicomputer to support Engineering Analysis	Provide computer resources to support structural and thermal analyses	240	
Physics and Astronomy	Goddard Space Flight Center 51-80-06	Gray Scale Imaging Augmentation	Provide displays of data from spacecraft instruments; spectogram data, which demands at least 16 levels of gray shading.	270	
Life Sciences	Johnson Space Center Bldg. 36, 72-80-04	Life Sciences Payloads Science Monitoring Area, Support Data Systems and Display Equipment	Provide real-time monitoring of life sciences shuttle/ spacelab experiments	310	FY 1980 Modifications to accomodate Life Sciences Equipment

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1980 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1980 OBLIGATIONS ($ IN THOUS.)	RELATED FACILITY PROJECT
Space Applications	Johnson Space Center Bldg. 17, 72-80-05	Agriculture and Forestry Applications Analysis System	Computer augmentation for support of multi-crop, multi-country remote sensing programs	1500	FY 1980 Modifications for earth resources computer
Space Applications	Goddard Space Flight Center 51-79-03	Landsat-D Ground Support Equipment	Ground Support Equipment needed for Landsat-D, including Operations Control Center (OCC) Data Management System (DMS), Landsat-D Assessment System (LAS) and Transportable Ground Station (TGS)	11000	
Tracking and Data Acquisition	Goddard Space Flight Center, Bldg. 14 51-80-01	Telemetry and Command Processor (TAC). TAC will capture the data, line decode/encode, establish frame sync and format data compatible with existing Payload Operating Control Centers (POCC)	Required to match the existing POCC's with command transmissions and non frame-synchronized telemetry data. This approach of inserting TAC front-end to existing POCC's minimizes the impact to on-going support	300	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1980 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1980 OBLIGATIONS ($ IN THOUS.)	RELATED FACILITY PROJECT
Tracking and Data Acquisition	Goddard Space Flight Center, Bldg. 14 51-80-02	POCC Pilot Model (POCCNET). This acquisition is the start of the design and procurement of several mini/midi computers and peripherals to be used as a nucleus for the new POCCNET pilot model POCC. The pilot model will demonstrate the concept of distributed processing virtual peripherals, common software shared resources and computer networking	Required to support the mission control workload in the 1980's and beyond in order to meet quick turnaround, increased support efficiency requirements and to minimize development and recurring costs with each new mission. The POCCNET concept is envisioned as very cost effective in the TDRSS/ STS/Spacelab/MMS era	2330	
Tracking and Data Acquisition	Goddard Space Flight Center, Bldg. 14 51-80-03	Mission Operations Computing Facility (MOCF). Required to replace obsolete Flight Dynamics and Attitude computation system and provide more real time support capability as well as greater reliability and economy of operation	Provides mission operations support computer capability to GSFC POCC's as required	5000	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1980 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1980 OBLIGATIONS ($ IN THOUS.)	RELATED FACILITY PROJECT
Tracking and Data Acquisition	Goddard Space Flight Center, Bldg. 14 51-80-04	Space Telescope Operations Control Center Data System	Required to conduct the real-time operation of the Space Telescope observatory with planned mission life of 15 years. The data system will require new space area of 5,000 square feet	3300	None, existing space will be made available
Tracking and Data Acquisition	Goddard Space Flight Center, Bldg. 14 51-08-05	Near Real-Time Transmission Facility to receive unprocessed Landsat data from selected STDN stations and forward processed Landsat data to Dept. of Interior facility at Sioux Falls, South Dakota	Required to support near real-time transmission of Landsat data	340	

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1980 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1980 OBLIGATIONS ($ IN THOUS.)	RELATED FACILITY PROJECT
Tracking and Data Acquisition	Jet Propulsion Laboratory 55-80-01	Network Data Processor. High order language development system for application software design. Includes hosted compiler for use with Deep Space Network standard operational ModComp computers to enable more efficient development and maintenance software being implemented	Required initially for application software development needed for replacement of obsolete DSN station monitor and control computers. Existing 15 year old systems require replacement due to unavailability of manufacturers components or maintenance support and can only be continued in operation by cannibalization of other systems	250	
Tracking and Data Acquisition	Wallops Flight Center 53-80-01	Replacement of the Rawin Set AN/GMD-1B of the Rawin Observation System. The AN/GMD-1B consists of a seven foot parabolic AZ-EL antenna with antenna control, receiver and parametric amplifier electronics. This system was designed in the 1940's and will be replaced by unit presently under development	This system is used to track weather instrumented balloons and rocket payloads and is used extensively to track and acquire data from constituent measuring payloads	250	

BUDGET SUPPLEMENTAL
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FISCAL YEAR 1979 ESTIMATES
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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1979

GENERAL STATEMENT

Supplemental Appropriation for Space Shuttle Program

A Supplemental Appropriation of $185.0 million is requested to provide the additional funding required for the Space Shuttle program. The Space Shuttle is the key element of a versatile, economical space transportation system that will provide a wide variety of national and international users with round trip access to space beginning in the 1980's. This Supplemental Appropriation, when added to the $1,443.3 million appropriated for FY 1979 would provide a total of $1,628.3 million for the Space Shuttle program within the Research and Development Appropriation.

The need for the additional funds results from technical problems encountered in development, manufacturing and testing of Space Shuttle systems; the need for design changes and weight reductions; and the requirements of prime contractors and subcontractors for increased engineering and manufacturing effort to fabricate hardware and conduct test activities. Intensive development and testing activity is proceeding in FY 1979 with the first orbital flight targeted for late 1979. Consistent with the Conference Report on the FY 1979 Appropriation, funding is being applied to Design, Development, Test and Evaluation activities at a rate which supports this plan; orbiter production activities are proceeding on a constrained basis; and the FY 1979 Supplemental Appropriation is being requested to restore funding for production activities. If the requested Supplemental Appropriation is not approved, it will be necessary to rebalance the program plan by adjusting the FY 1979 development and test activities with a resultant delay of several months in first orbital flight and by delaying production activities with a resultant six to twelve month delay in delivery of the second, third, and fourth orbiter vehicles. The effect of such a delay on overall Space Shuttle program costs is estimated at $400-600 million.

The following table presents a comparison of the funding plan for Space Shuttle Research and Development contained in the FY 1979 Budget Request with the current plan including the requested Supplemental Appropriation:

	Millions of Dollars
FY 1979 Budget Request	$1,439.3
Amount added by Congress to FY 1979 Authorization and Appropriation for procurement of long lead time items for a fifth orbiter	4.0
Total Amount Authorized and Appropriated for FY 1979	$1,443.3
Total Current Estimate	$1,628.3
Requested Supplemental Authorization and Appropriation	$185.0

Appropriation summary tables, proposed language for the requested authorization and appropriation, and a more specific narrative statement of program requirements follow.

BUDGET SUPPLEMENTAL

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

BUDGET SUMMARY

(Thousands of Dollars)

	FY 1978 Actual	Budget Plan FY 1979 Presently Available	Budget Plan FY 1979 Proposed Supplemental	Budget Plan FY 1979 Revised Estimate	FY 1980 Budget Estimate
SPACE TRANSPORTATION SYSTEMS	1,751,500	1,824,500	185,000	2,009,500	1,904,000
Space shuttle	1,349,200	1,443,300	185,000	1,628,300	1,366,000
Space flight operations	267,800	309,700	---	309,700	467,300
Expendable launch vehicles	134,500	71,500	---	71,500	70,700
SPACE SCIENCE	404,700	505,400	---	505,400	601,600
Physics and astronomy	224,200	282,900	---	282,900	337,500
Planetary exploration	147,200	182,400	---	182,400	220,200
Life sciences	33,300	40,100	---	40,100	43,900
SPACE AND TERRESTRIAL APPLICATIONS	243,900	283,900	---	283,900	344,400
Space applications	234,800	274,800	---	274,800	332,300
Technology utilization	9,100	9,100	---	9,100	12,100
AERONAUTICS AND SPACE TECHNOLOGY	333,200	376,400	---	376,400	419,700
Aeronautical research and technology	228,000	264,100	---	264,100	300,300
Space research and technology	97,700	107,300	---	107,300	116,400
Energy technology	7,500	5,000	---	5,000	3,000
SPACE TRACKING AND DATA SYSTEMS	278,300	302,000	---	302,000	332,800
TOTAL RESEARCH AND DEVELOPMENT	3,011,600	3,292,200	185,000	3,477,200	3,602,500
OUTLAYS	2,988,697	3,148,500	163,200	3,311,700	3,475,700

BUDGET SUPPLEMENTAL

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Research and Development
Budget Summary By Subfunction

	Subfunction		1978 Actual	FY 1979 Presently Available	FY 1979 Proposed Supplemental	FY 1979 Revised Estimate	FY 1980 Budget Estimate
253	Space flight	BA	1,751,500	1,824,500	185,000	2,009,500	1,904,000
		O	1,835,428	1,770,800	163,200	1,934,000	1,906,200
254	Space science, applications and technology	BA	753,800	901,600	---	901,600	1,065,400
		O	668,576	837,000	---	837,000	974,800
255	Supporting space activities	BA	278,300	302,000	---	302,000	332,800
		O	272,445	297,100	---	297,100	313,400
250	Subtotal, General Science, Space and Technology	BA	2,783,600	3,028,100	185,000	3,213,100	3,302,200
		O	2,776,449	2,904,900	163,200	3,068,100	3,194,400
402	Air Transportation	BA	228,000	264,100	---	264,100	300,300
		O	212,248	243,600	---	243,600	281,300
	Total	BA	3,011,600	3,292,200	185,000	3,477,200	3,602,500
		O	2,988,697	3,148,500	163,200	3,311,700	3,475,700

BA -- Budget Authority
O -- Outlays

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

AUTHORIZATION BILL

A BILL

To authorize a supplemental appropriation to the National Aeronautics and Space Administration for Research and Development.

Paragraph (1) of subsection 1(a) of the National Aeronautics and Space Administration Authorization Act, 1979 (Public Law 95-401), is amended by striking out "$1,443,300,000" and inserting in lieu thereof "$1,628,300,000."

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APPROPRIATION LANGUAGE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

For an additional amount for "Research and Development", $185,000,000; to remain available until September 30, 1980.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1979 SUPPLEMENTAL REQUIREMENT

OFFICE OF SPACE TRANSPORTATION SYSTEMS — SPACE SHUTTLE PROGRAM

PROGRAM STATUS:

Space Shuttle development is in a period of peak effort and well on the way toward the first orbital flight, planned for late 1979. All major Shuttle system elements are proceeding in test and manufacture and all major ground test programs are now being conducted. The test elements for the Mated Vertical Ground Vibration Test (MVGVT) have been delivered to the Marshall Space Flight Center (MSFC) and testing is now in progress. This MVGVT program will verify the vibration characteristics during liftoff and at other times during the ascent profile. The tests will be completed in early 1979. The Main Propulsion Test (MPT) series was started in 1978 at the National Space Technology Laboratories (NSTL) and will continue through 1979 and part of 1980. This includes three main engines, mounted on an orbiter aft fuselage, and an external tank.

FY 1979 activities support preparations for the first orbital flight planned in late 1979. The Orbiter 102, which will be used for the orbital flight tests, is in final assembly and checkout at Palmdale, California. In early 1979, this orbiter will be delivered to KSC where it will begin preparations for launch. The orbiter structural test article was completed by Rockwell International and transferred to the Lockheed plant in Palmdale for structural testing, which started in 1978 and is scheduled for completion in mid-1979. Engine testing, temporarily suspended because of an engine failure in December 1978, which essentially destroyed an engine, was resumed on January 29 after the modifications were completed. Prior to this incident, engine testing was proceeding at a good pace, with over 5,000 seconds accumulated on one flight configured engine. The first set of flight engines will be acceptance tested at NSTL in Mississippi and, together with associated ground support equipment, will be delivered to KSC for installation on Orbiter 102 in 1979.

Fabrication of three external tank test articles has been completed, and are in use for structural, vibration, and main propulsion testing. The second and third solid rocket motor development firings were accomplished during 1978, and the fourth and final development firing plus three qualification firings are planned in 1979. Delivery of the external tank and the solid rocket motors to KSC for the first orbital flight is scheduled during the first half of 1979. In addition, some of the solid rocket booster components for the first orbital flight were delivered to KSC during 1978, while the remaining solid rocket booster components are scheduled for delivery in the first half of 1979.

Facilities installation and site activation is proceeding at both KSC and at the Dryden Flight Research Center (DFRC) in California to support STS-1. KSC facilities such as the Vehicle Assembly Building, Mobile Launch Platform, Orbiter Processing Facility, Launch Pad A, and the Rotating Service Structure with the Payload Changeout Room are all progressing satisfactorily. The computerized launch processing system (LPS) and the ground support equipment at KSC and DFRC are in the final stages of completion and software validation is underway. Flight equipment will be checked out and processed for STS-1 after it arrives at KSC for launch

In August 1978, a comprehensive program review was undertaken to assess the significance of technical problems encountered in several areas including the Space Shuttle main engines, orbiter thermal protection subsystem production and installation, orbital maneuvering subsystem pod fabrication, solid rocket booster manufacture and test, external tank thermal protection application, and flight software development. The conclusion of the detailed review indicated that while substantial progress had been achieved, the overall program progress was slower than planned at the time the FY 1979 budget was prepared. The main engine development continued to be a primary technical concern. Importantly, the review also concluded that it is a technically sound engine and that a rapid accumulation of test seconds can be expected and indeed has been demonstrated. Approximately 35,000 seconds of test firings have been run, more than 10,000 of these at rated power levels. Based on the assessment of the engine status and the status of the other elements of the program, it was determined that it was reasonable to continue to plan to accomplish the first orbital test during 1979. Achievement of this target is dependent on successful completion of the key remaining ground tests and on encountering no major unforseen problems.

The program review also identified the need for additional FY 1979 funding of $185.0 million to provide timely support for urgent program requirements. This amount, which is requested as a Supplemental Appropriation, when added to the $1,443.3 million appropriated for FY 1979 for the Space Shuttle results in total FY 1979 budget authority of $1,628.3 million. These additional funding requirements are not due to any single element, but occur in a number of program areas. The additional funding is needed to solve technical problems; to provide for necessary changes in many elements of the program; and to meet the requirements of prime contractors and subcontractors for increased engineering and manufacturing effort to fabricate hardware and conduct test activities.

In summary, the progress at this critical phase of the development effort has been substantial, but has not sustained the pace necessary to accomplish the original FY 1979 budget plan thus making it necessary to adjust program schedules and request a supplemental appropriation. A summary of additional funding requirements by program element follows:

Summary by Program Element	Basis for FY 1979 Authorization and Appropriation	Current Estimate	Additional Funding Requested
	(Millions of Dollars)		
Orbiter	937.5	999.0	+61.5
Main Engine	194.7	242.7	+48.0
External Tank	80.5	107.6	+27.1
Solid Rocket Booster	63.5	100.2	+36.7
Launch and Landing	139.1	158.6	+19.5
Spares and Equipment	28.0	20.2	-7.8
TOTAL	1,443.3	1,628.3	+185.0

BASIS OF SUPPLEMENTAL FUND REQUIREMENT:

The requirement for the requested supplemental appropriation in FY 1979 is a result of development problems, program changes, and the need for more work than was previously planned, particularly in the fabrication and assembly of flight and test hardware and in systems qualification and certification. The impact of these difficulties has been hardware schedule delays, increased engineering and manufacturing requirements in prime and subcontractor efforts, and significant deferrals of work content into FY 1979. Fabrication activities on the second and subsequent orbiters have been proceeding on a constrained basis as funding is applied to keep development efforts on the new schedule directed towards the first orbital flight in late 1979. The additional funding requested in the Supplemental Appropriation will be applied to continue the development efforts on schedule and to restore the funding needed for follow-on orbiter fabrication activities.

RESEARCH AND DEVELOPMENT

	Basis for FY 1979 Authorization and Appropriation	Current Estimate	Additional Funding Requested
	(Thousands of Dollars)		
Orbiter	937,500	999,000	61,500

STATUS:

During FY 1979, the emphasis will be on completion of manufacture and assembly of Orbiter 102, the testing required to certify Orbiter 102 for the first orbital flight test, and continuation of fabrication and assembly of the follow-on orbiters.

The structural test article (STA) which has a flight-type orbiter airframe, was transferred to the Lockheed test facility at Palmdale, California, early in 1978 and is currently undergoing static load testing. These tests are scheduled for completion in 1979, after which the STA will be converted to an orbital vehicle (099). Satisfactory completion of structural testing is required for flight loads certification of Orbiter 102.

The orbiter main propulsion test article along with three main engines and an external tank was installed in the test stand at NSTL and test firings started in 1978. Testing, to acquire propulsion system performance data as well as acoustic data, will resume after main engine modifications are completed and will continue through 1979.

Orbiter 101 is currently being used in the full-scale ground vibration tests at MSFC. Results of these tests, will be correlated with data from quarter scale testing to verify the structural integrity of the shuttle system.

Approximately 600 hardware certification requirements are necessary for the first flight of Orbiter 102. All subsystems require certification including structural, thermal protection, main propulsion, reaction control, communications, guidance and navigation, orbital maneuvering, and environmental control. These certification tests are scheduled for completion late in FY 1979.

Preliminary orbital flight software is being used to conduct orbital flight verification tests. Initial checkout of the Palmdale and KSC test procedures, detailed evaluations of the flight control interaction with the dynamic model interfaces, and study of the remote manipulator system avionics

interactions will be performed at the Shuttle Avionics Integration Laboratory (SAIL). Facility acceptance tests of the SAIL at the Johnson Space Center (JSC) with the MSFC Mated Elements System will be completed in mid FY 1979. This will assure that these facilities are ready to start verification of the complete avionics system and its interfaces with the Shuttle vehicle. Acceptance test of the Flight Systems Laboratory (including the Avionics Development Laboratory, Flight Control Hydraulics Laboratory, crew station, and backup flight control system flight software verification facility) at Rockwell in Downey, California, will also be completed.

During FY 1979, manufacture and assembly of Orbiter 102 will continue and delivery to KSC is scheduled for March 1979. Systems installation, final assembly, thermal protection system installation and final checkout are all proceeding. Some effort, particularly the thermal protection system installation, will be completed after delivery to KSC.

After completion of the planned testing of the structural test article (STA), it will be returned to the Rockwell plant at Palmdale to begin conversion to an orbital configuration (Orbiter 099). During FY 1979, fabrication of subsystems for OV-099 will continue at the subcontractor level and fabrication of the crew module at the prime contractor will also be continued.

Fabrication and assembly of the major subsystems of Orbiter 103, which is scheduled for delivery early in FY 1983, has begun at Rockwell International and at the major structural subcontractors. The crew module and the forward and aft-fuselage elements are in assembly at Rockwell, and the wings, the vertical stabilizer, and the mid-fuselage elements are in assembly at Rockwell's subcontractors. Fabrication of the thermal protection system tiles has also begun. Some long lead ordering of critical parts will also be accomplished for Orbiter 104 during FY 1979. Efforts have initiated during FY 1979 to identify and define a weight reduction program for implementation on Orbiters 099, 103, and 104. During FY 1979, NASA is negotiating a contract with the Canadians for remote manipulator flight systems, auxiliary equipment, ground handling and servicing support for the follow-on orbiters. Funds appropriated for FY 1979 to maintain the option for possible fabrication of a fifth orbiter will also be used to begin procurement of critical long lead items. NASA will only order items which are common to a four or five orbiter program and not specifically for a fifth orbiter.

BASIS OF SUPPLEMENTAL REQUEST:

The increase in funding requirements for FY 1979 is caused by a combination of mandatory design changes, technical problems in FY 1978 that caused work to be deferred into FY 1979 and the need for more work than was previously planned. Last year, the completion of manufacturing and

assembly of Orbiter 102 and delivery to KSC was scheduled for October 1978. During FY 1978, test results, engineering analysis, and systems evaluation identified the need for more technical changes than were previously anticipated. These changes included an increase in the helium purge system, addition of the backup flight control system, modification of the engine base heat shield and additional systems integration tasks. The need for more work than was planned occurred in a number of areas in FY 1978. The effort required by the prime contractor to manufacture the primary structures for Orbiter 102, install the subsystems, and assemble the vehicle was greater than previously estimated. A number of subcontractors also experienced technical problems and increased cost requirements in FY 1978. For example, an increase in the complexity of reusable surface insulation tiles was experienced as requirements were better defined; the production yield of acceptable tiles was lower than estimated; and a two month strike delayed deliveries. In addition, changes were required for the on-board computers; producability problems were experienced with the reaction control system and orbital maneuvering system; technical problems with the auxiliary power unit resulted in additional test and resolution effort; and the S-band radar system required more effort than was previously planned on the payload and network equipment as specifications changed and hardware requirements increased. These changes, technical problems and increases in required effort resulted in deferral of work into FY 1979 along with the need for increased funding. The current Orbiter 102 delivery is planned for March 1979 and subcontractor deliveries, systems installations, and final assembly are proceeding. The thermal protection system tile production and installation continues to be the most difficult problem and this work will be completed at KSC in parallel with Orbiter checkout activity.

Increased requirements also occurred in areas other than the prime contractor's effort. Orbiter software problems and a large number of changes caused increased requirements in FY 1979. Cost increases also occurred on the extravehicular mobility units. A schedule stretchout of the main propulsion tests (MPT) due to main engine problems and implementation of a phased approach to the main propulsion certification requires additional funds in FY 1979. A schedule delay and the need for additional funds also occurred for the mated vertical-ground vibration tests (MVGVT) due to hardware delays and the identification of additional test requirements.

An orbiter weight savings program has been implemented in FY 1979 to identify and define areas where weight can be reduced for Orbiters 099, 103, and 104.

These increased requirements were partially offset by the deferral of manufacturing and assembly efforts for Orbiters 099, 103, and 104, consistent with the revised delivery schedule which delays the delivery of OV-099 seven months and OV-103 and OV-104 three months.

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	Basis for FY 1979 Authorization and Appropriation	Current Estimate	Additional Funding Requested
	(Thousands of Dollars)		
Main Engine	194,700	242,700	48,000

STATUS:

During FY 1978, problems developed during testing with a number of engine components, which caused the main engine project to fall behind in accumulated engine test time. Investigation of these problems has identified failure modes and causes, and modifications are being tested. As a result, engine testing was proceeding at a good pace until a recent (December 27, 1978) failure destroyed most of the integral parts of an engine (2001) undergoing acceptance testing. This caused a temporary suspension of the testing. The cause of the failure (in the main liquid oxygen valve) has been determined and modifications are now being made to all engines to correct this problem. The first engine with modified liquid oxygen valves was test fired on January 29 at Santa Susana and testing is now proceeding.

Engine testing is still a pacing item to perform STS-1 in 1979. However, progress on the main engine development since the summer of 1978 has been significant. A total of 6,600 seconds at the rated power level (RPL) of 100% was achieved in one month and over 5,000 seconds were recorded on one flight configured engine including six tests at RPL, each for the full mission duration of 520 seconds. A total of about 500 tests have been conducted accumulating almost 35,000 seconds of operation, with about 75 tests and 11,000 seconds at RPL. In addition to the two existing test stands at NSTL, an engine test stand has been activated at Santa Susana in California.

Testing will continue on flight configured engines during 1979, leading to the main engine flight certification for STS-1. Single engine testing will be intensive in order to prove the durability of each element of the system. Rigorous examination of each hardware component will be accomplished as a part of this thorough test activity. In FY 1979, the first set of three flight engines and one spare will be delivered to KSC. Fabrication of additional development engines for testing will continue in FY 1979.

FY 1979 funding also provides for continuation of long lead material and component procurements for these additional flight engines required for development backup and the operational orbiter fleet. Engine component procurements include hot gas manifold and preburner body forgings, turbopump castings, main combustion chamber parts and selected raw materials and plate stock for engine component fabrication. In addition, fabrication of liquid hydrogen and liquid oxygen high and low pressure turbopump components has been initiated and, assembly of the second set of flight engines will begin during FY 1979.

In addition to the manufacture and test work by Rocketdyne and the subcontractors, the main engine activities provide the necessary project support efforts. These efforts include the procurement of propellants for test firing the engine and its components, the maintenance of the engine systems hardware simulation laboratory, logistics support, and the evaluation of materials and processes.

BASIS OF SUPPLEMENTAL REQUEST:

In early FY 1979, NASA activated a third engine test stand at Santa Susana, which was previously unplanned, and began testing in order to enhance development progress by establishing an increased capability to conduct engine system testing. This additional capability is in response to the recommendations of the National Research Council's ad hoc committee for review of the Space Shuttle main engine development program (Covert Committee). Implementation of other recommendations by the Covert Committee which resulted in increased funding requirements for FY 1979 included the acceleration of follow-on engines to be available in the event additional test hardware is needed and the acquisition of additional critical parts. FY 1979 funding requirements also increased due to the deferral of work as a result of engine test problems in FY 1978, resolution of engine test problems, and increased engine manufacturing and assembly requirements, resulting from changes and redesigns made as a result of engine test solutions.

	Basis for FY 1979 Authorization and Appropriation	Current Estimate	Additional Funding Requested
	(Thousands of Dollars)		
External Tank	80,500	107,600	27,100

STATUS:

Early in FY 1979, structural testing of the liquid hydrogen test tank was initiated at MSFC. This activity will be completed in 1979, along with the oxygen tank structural verification tests which began in FY 1978.

During the first quarter of FY 1979, the main propulsion test tank was upgraded at NSTL to a full flight configuration. A complete test tank is also being used in the full scale ground vibration tests, together with the Orbiter "Enterprise" and solid rocket boosters. This testing is planned for completion in early 1979.

Four flight tanks are currently in various stages of assembly and checkout at the Michoud Assembly Facility (MAF) in Louisiana. Improvements in some manufacturing techniques were required, particularly with regard to the application of thermal protection materials. Some fabrication delays were encountered, and delivery of the first flight tank to KSC is now expected in the first half of 1979 to support the planned STS-1 launch. Fabrication of the final two DDT&E flight external tanks will be initiated during FY 1979, and the second flight tank is expected to be delivered to KSC the end of the fiscal year.

BASIS OF SUPPLEMENTAL REQUEST:

Technical design changes were largely responsible for the increase in FY 1979 funding requirements. Revised aerodynamic loads and a change in the predicted ascent aerothermal environments resulted in a redesign of the external propulsion lines and cable tray and a large increase in the amount of thermal protection coverage required. Increased requirements also resulted from the deferral of manufacture and assembly effort into FY 1979 as a result of these design changes and the need for more work than was previously planned. Additional maintenance and test support due to the stretchout of the main propulsion, ground vibration, and structural test programs, and additional support at Michoud Assembly Facility as a result of the change requirements and fabrication delays also resulted in additional funding requirements.

	Basis for FY 1979 Authorization and Appropriation	Current Estimate	Additional Funding Requested
	(Thousands of Dollars)		
Solid Rocket Booster	63,500	100,200	36,700

STATUS:

The third solid rocket development motor (DM-3) firing occurred in October 1978 and the fourth (DM-4) and final firing is scheduled for February 1979. Both of these firings were delayed to incorporate the new inhibitor design. The manufacture of three qualification motors has been initiated and testing will follow the completion of the development motor test program with the three qualification motor firings scheduled prior to the STS-1 launch.

The SRB structural test program was initiated at MSFC and testing will continue in FY 1979. The SRB hardware required for the mated ground vibration test was delivered to MSFC in 1978 and testing is currently in progress.

The manufacture of flight motors for the first test flight (STS-1) has begun and delivery of the flight set of two SRM's to KSC will be completed by mid-1979. The manufacture of flight motors for the follow-on orbital flight tests will continue through FY 1979.

Verification testing will continue in FY 1979 on the SRB subsystems including the thrust vector control and booster separation motor subsystems. In addition, the booster assembly contractor will complete activation of the Refurbishment Subassembly Facility at KSC leading to the assembly and checkout of the SRB for the first orbital flight.

BASIS OF SUPPLEMENTAL REQUEST:

Increased requirements in FY 1979 occurred in most of the subsystem areas within the SRB. In the structures area a number of changes occurred including modification to the aft skirt skin forming tools and changes to the heat shield attachments. Cost increases were also caused by welding and assembly problems of the forward and aft skirts. Redesign changes to components being procured by the booster assembly contractor and the deferral of ground support equipment from FY 1978 resulted in the need for additional funding. In addition, checkout software support to the Launch Processing System at KSC in the Refurbishment Subassembly Facility was greater than previously planned.

Other subsystems such as integrated electronics, thrust vector control and the recovery system all experienced changes due to test results and engineering updates. The prime contractor for the solid rocket motor experienced increased cost requirements. The development motor firings caused component redesign, inhibitor modifications, and tooling redesigns resulting in cost increases. Also the labor requirements for processing the development and early flight rocket motors were greater than previously estimated.

	Basis for FY 1979 Authorization and Appropriation	Current Estimate	Additional Funding Requested
	(Thousands of Dollars)		
Launch and Landing	139,100	158,600	19,500

STATUS:

Approximately 1,430 design models of ground support equipment (GSE) for station sets have been

defined, including some 810 provided by the vehicle development contractors and 620 provided by separate KSC GSE procurements. All of the GSE is on contract. About 55% of the development contractor GSE and 90% of the KSC GSE have been received. A major portion of the effort remaining in FY 1979 involves receiving the remaining GSE, installing and checking it out, and activating the resulting station sets.

All hardware and system software for the central data subsystem have been accepted. All major launch processing system operating software releases have been made to support the ground checkout software programs required for launch operations.

During 1979, the final phase of construction of facilities required for the first orbital flight will be completed. The launch processing system will be ready for mating with ground support equipment. All station sets in the first flow processing line will be activated and will complete operational readiness checkout before the first set of flight hardware reaches each respective station. Launch operations procedures will be prepared and verified for this same readiness schedule. Orbiter 102, the first flight sets of main engines and solid rocket boosters, and the first flight ET will be delivered to KSC starting in early 1979.

The development contractors' support activities and manpower buildup at KSC will continue and reach a peak prior to the STS-1 launch. The development contractors constitute the bulk of the launch team and are also the operators of the launch processing station sets, launch support equipment, and the GSE. Processing of the vehicle for the first orbital flight will commence early in 1979. Flight elements will be assembled, checked out, serviced and launched for the first manned orbital flight. In addition, launch processing of some elements of the follow-on orbital flight tests will be in progress during 1979.

The development contractors' onsite launch support efforts at KSC have been initiated with Rockwell International (including both orbiter and main engine contractors), Martin Marietta, United Space Boosters, Inc., and Thiokol. These contractors are preparing specifications, procedures and test documentation for vehicle assembly, test, servicing, checkout and launch.

BASIS OF SUPPLEMENTAL REQUEST:

The increase in the FY 1979 funding estimate is due to the deferral of effort from FY 1978 and increased requirements in FY 1979. Due to the delay in shipment of the first flight elements to KSC, efforts such as ground support equipment (GSE) procurement, installation and checkout; propellant purchases; and launch processing system equipment buys were deferred into FY 1979. In addition, more ground support equipment spares were required, and the effort required to activate the various station sets, such as the orbiter processing facility, hypergolic system maintenance facility, and SRB disassembly area, were greater than previously planned.

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	Basis for FY 1979 Authorization and Appropriation	Current Estimate	Change in Funding Requested
	(Thousands of Dollars)		
Spares and Equipment	28,000	20,200	-7,800

STATUS:

Shuttle spares and equipment include orbiter flight and ground support equipment spares, main engine spares, KSC launch site ground support equipment spares, crew equipment, and solid rocket booster and external tank rate tooling required to increase the rate of production during the operational years. In FY 1979, the crew equipment being procured is primarily additional extra-vehicular mobility units and portable oxygen systems required by the astronaut crew for the early operational period. External tank tooling for assembly, thermal protection installation, welding, and handling will be procured in FY 1979 to increase the production rate capability of External Tanks. Solid Rocket Booster tooling in FY 1979 includes additional nozzle, propellant loading and case preparation tooling and associated handling equipment.

BASIS OF SUPPLEMENTAL REQUEST:

Consistent with the schedule adjustment of the first orbital flight and the associated delay of nine months in the initial operating capability, crew equipment and orbiter flight spares have been replanned with requirements rephased into FY 1980.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Program and Financing (in thousands of dollars)

A-11-39B

Research and Development

Identification Code: 80-0108-4-1-999	Budget Plan (amounts for research and development actions programmed)			Costs and Obligations		
	1979	1979	1979	1979	1979	1979
Program by activities:	Presently available	Revised estimate	Proposed supplemental	Presently available	Revised estimate	Proposed supplemental
Direct program:						
1. Space transportation systems:						
(a) Space shuttle	1,443,300	1,628,300	185,000	1,408,700	1,593,700	185,000
(b) Space flight operations	309,700	309,700	---	306,900	306,900	---
(c) Expendable launch vehicle development and support	42,600	42,600	---	95,400	95,400	---
2. Scientific investigations in space:						
(a) Physics and astronomy	300,400	300,400	---	285,700	285,700	---
(b) Planetary exploration	182,400	182,400	---	182,000	182,000	---
(c) Life sciences	40,100	40,100	---	38,100	38,100	---
3. Space and terrestrial applications:						
(a) Space applications	286,200	286,200	---	284,900	284,900	---
(b) Technology utilization	9,100	9,100	---	10,100	10,100	---
4. Space research and technology	107,300	107,300	---	109,400	109,400	---
5. Aeronautical research and technolog	264,100	264,100	---	244,000	244,000	---
6. Energy technology	5,000	5,000	---	5,700	5,700	---
7. Supporting activity:						
(a) Tracking and data acquisition	302,000	302,000	---	301,100	301,100	---
Total direct program	3,292,200	3,477,200	185,000	3,272,000	3,457,000	185,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Program and Financing (in thousands of dollars) A-11-398

Research and Development

Identification Code: 80-0108-4-1-999	Budget Plan (amounts for research and development actions programmed)			Costs and Obligations		
	1979	1979	1979	1979	1979	1979
	Presently available	Revised estimate	Proposed supplemental	Presently available	Revised estimate	Proposed supplemental
Reimbursable program:						
1. Space transportation systems:						
(a) Space shuttle	34,594	34,594	---	29,860	29,860	---
(b) Space flight operations	63,574	63,574	---	61,710	61,710	---
2. Scientific investigations in space:						
(a) Physics and astronomy	600	600	---	3,440	3,440	---
(c) Life sciences	419	419	---	470	470	---
3. Space and terrestrial applications:						
(a) Space applications	220,973	220,973	---	217,890	217,890	---
(b) Technology utilization	7,293	7,293	---	8,020	8,020	---
4. Space research and technology	---	---	---	1,170	1,170	---
5. Aeronautical research and technology	16,692	16,692	---	18,240	18,240	---
6. Energy technology	158,400	158,400	---	161,830	161,830	---
7. Supporting activity:						
(a) Tracking and data acquisition	3,655	3,655	---	3,570	3,570	---
Total, reimbursable program	506,200	506,200	---	506,200	506,200	---
Total program costs, funded	3,798,400	3,983,400	185,000	3,778,200	3,963,200	185,000
Change in selected resources (undelivered orders and stores)	---	---	---	377,548	377,548	---
10.00 Total	3,798,400	3,983,400	185,000	4,155,748	4,340,748	185,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Program and Financing (in thousands of dollars)

A-11-391

Research and Development

Identification Code: 80-0108-4-1-999	Budget Plan (amounts for research and development actions programmed)			Costs and Obligations		
	1979	1979	1979	1979	1979	1979
Financing:	Presently available	Revised estimate	Proposed supplemental	Presently available	Revised estimate	Proposed supplemental
Offsetting collections from:						
11.00 Federal funds	-313,184	-313,184	---	-313,184	-313,184	---
14.00 Non-Federal sources	-193,016	-193,016	---	-193,016	-193,016	---
Budget Authority:						
21.40 Unobligated balance available, start of year:						
For completion of prior year budget plans:						
Direct	---	---	---	-240,403	-240,403	---
Reimbursable	---	---	---	-116,945	-116,945	---
40.00 Budget authority (appropriation)	3,292,200	3,477,200	185,000	3,292,200	3,477,200	185,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Program and Financing (in thousands of dollars) A-11-398

Research and Development

Identification Code: 80-0108-4-1-999	Budget Plan (amounts for research and development actions programmed)			Costs and Obligations		
	1979	1979	1979	1979	1979	1979
	Presently available	Revised estimate	Proposed supplemental	Presently available	Revised estimate	Proposed supplemental
Relation of obligations to outlays:						
71.00 Obligations incurred, net				3,649,548	3,834,548	185,000
72.40 Obligated balance, start of year				515,865	515,865	---
74.40 Obligated balance, end of year				-1,016,913	-1,038,713	-21,800
90.00 Outlays				3,148,500	3,311,700	163,200

Note: Reconciliation of budget plan to obligations:	979 estimate		
	Presently available	Revised estimate	Proposed supplemental
Total budget plan	3,798,400	3,983,400	185,000
Add obligations of prior year budget plans	357,348	357,348	---
Total obligations	4,155,748	4,340,748	185,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
RESEARCH AND DEVELOPMENT
OBJECT CLASSIFICATION (in thousands of dollars)

A-11-34

Identification code 80-0108-4-1-999	1979	1979	1979
Direct obligations:	Presently Available	Revised Estimate	Proposed Supplemental
11.1 Permanent positions			
11.3 Positions other than permanent			
11.5 Other personnel compensation			
11.8 Special personal services payments			
Total personnel compensation			
Personnel benefits:			
12.1 Civilian			
13.0 Benefits for former personnel			
21.0 Travel and transportation of persons			
22.0 Transportation of things	8,950	9,510	560
23.1 Standard level user charges	141	141	---
23.2 Communications, utilities and other rent	44,480	46,880	2,400
24.0 Printing and reproduction	2,900	3,090	190
25.0 Other services	3,246,590	3,416,970	170,380
26.0 Supplies and materials	143,250	150,650	7,400
31.0 Equipment	81,940	86,010	4,070
32.0 Lands and structures	1,550	1,550	---
33.0 Investments and loans			
41.0 Grants, subsidies, and contributions	2,802	2,802	---
42.0 Insurance claims and indemnities			
43.0 Interest and dividends			
44.0 Refunds			
99.0 Total direct obligations	3,532,603	3,717,603	185,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
RESEARCH AND DEVELOPMENT
OBJECT CLASSIFICATION (in thousands of dollars)

A-11-34

Identification code 80-0108-4-1-999	1979	1979	1979
Reimbursable obligations:	Presently Available	Revised Estimate	Proposed Supplemental
~~11.1 Permanent positions~~			
~~11.3 Positions other than permanent~~			
~~11.5 Other personnel compensation~~			
~~11.8 Special personal services payments~~			
~~Total personnel compensation~~			
Personnel benefits:			
~~12.1 Civilian~~			
~~13.0 Benefits for former personnel~~			
~~21.0 Travel and transportation of persons~~			
22.0 Transportation of things	820	820	---
~~23.1 Standard level user charges~~			
23.2 Communications, utilities and other rent	2,030	2,030	---
24.0 Printing and reproduction	170	170	---
25.0 Other services	595,745	595,745	---
26.0 Supplies and materials	10,165	10,165	---
31.0 Equipment	12,175	12,175	---
32.0 Lands and structures	2,040	2,040	---
~~33.0 Investments and loans~~			
~~41.0 Grants, subsidies, and contributions~~			
~~42.0 Insurance claims and indemnities~~			
~~43.0 Interest and dividends~~			
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Total reimbursable obligations	623,145	623,145	---
99.0 Total obligations	4,155,748	4,340,748	185,000

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