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DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT—INDEPENDENT AGENCIES APPROPRIATIONS FOR 1976

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HEARINGS

BEFORE A

SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS HOUSE OF REPRESENTATIVES

NINETY-FOURTH CONGRESS

FIRST SESSION

SUBCOMMITTEE ON HUD—INDEPENDENT AGENCIES

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PART 2

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 1976

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PART 2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Printed for the use of the Committee on Appropriations

U.S. GOVERNMENT PRINTING OFFICE
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HUD–INDEPENDENT AGENCIES APPROPRIATIONS FOR FISCAL YEAR 1976

TUESDAY, MARCH 4, 1975.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WITNESSES

DR. JAMES C. FLETCHER, ADMINISTRATOR
DR. GEORGE M. LOW, DEPUTY ADMINISTRATOR
DR. ROCCO A. PETRONE, ASSOCIATE ADMINISTRATOR
WILLIS H. SHAPLEY, ASSOCIATE DEPUTY ADMINISTRATOR
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DR. HARRIETT G. JENKINS, ASSISTANT ADMINISTRATOR FOR EQUAL OPPORTUNITY PROGRAMS
GERALD D. GRIFFIN, ASSISTANT ADMINISTRATOR FOR LEGISLATIVE AFFAIRS

Mr. BOLAND. The committee will come to order.

We are delighted to have with us this morning witnesses from the National Aeronautics and Space Administration. I would like to introduce to the NASA people the new members of the committee, Max Baucus from Montana, Yvonne Burke from California, and Bill Young from Florida. So that the new members will know who the top personnel in NASA are, I would like to introduce Dr. James C. Fletcher, Dr. George M. Low, Dr. Rocco A. Petrone, Mr. Willis H.

Shapley, Mr. Elmer Groo, the Associate Administrator for Center Operations—are you new?

Mr. GROO. Yes, sir.

Mr. BOLAND. Welcome.

Mr. William Lilly, who is the NASA Comptroller and has been with them for many years and has all the answers. We have never found Bill Lilly wrong.

Mr. Neil Hosenball, the Acting General Counsel. Are you new?

Mr. HOSENBALL. No, sir. I have been here before.

Mr. BOLAND. Mr. John F. Yardley, the Associate Administrator for Manned Space Flight; Dr. Noel W. Hinners, the Associate Administrator for Space Science; Mr. Charles W. Mathews, the Associate Administrator for Applications; Dr. Alan M. Lovelace, the Associate Administrator for Aeronautics and Space Technology; Mr. Gerald M. Truszynski, the Associate Administrator for Tracking and Data Acquisition; Dr. Harrison Schmitt, the Assistant Administrator for Energy Programs—Dr. Schmitt is new, at least before this committee. He is a former astronaut and has had a distinguished career with NASA. We are delighted to have you with us and delighted to know that you will be in NASA's energy program.

Mr. Edward Z. Gray, the Assistant Administrator for Industry Affairs and Technology Utilization.

Gen. Robert H. Curtin, the Director of Facilities, Office of the NASA Comptroller; Dr. Harriett G. Jenkins, Assistant Administrator for Equal Opportunity Programs; and Mr. Gerald D. Griffin, Assistant Administrator for Legislative Affairs.

I presume all of you know Gerry Griffin.

Have you met all of the new members, Gerry?

Mr. GRIFFIN. Yes, sir.

BUDGET REQUEST FOR FISCAL YEAR 1976 AND TRANSITION PERIOD

Mr. BOLAND. In fiscal year 1976 you are seeking 3.53 billion. That is an increase of approximately $307 million over your fiscal year 1975 budget. You are also seeking $958,900,000 in transition funds for the period from July 1, 1976 through September 30, 1976. You are requesting 24,316 permanent positions in 1976. There is no change from fiscal year 1975 to fiscal year 1976.

ECONOMIC BENEFITS FROM NASA PROGRAMS

I want to make one or two observations about today's space program. I have heard it said that the space program is a national luxury. It is said on the floor of the Congress, said outside the Halls of Congress, and said in a number of places that the Nation's space program is nice to do if we can afford it. Now, of course, we are in a position where the Federal budget deficit for just one year is starting to look like NASA's figures covering a whole decade. The administration was projecting a deficit of more than $50 billion for the fiscal year 1976 Federal budget. Now it appears that that deficit may well be up to $100 million or more.

I have sat in this committee for some time now, ever since NASA was created. I don't think that the Nation can afford not to do the

things we are doing in the aeronautics and space program. I point to a report which indicates that in the 18-year period from the beginning of the Apollo program to the start of the Space Shuttle flights, this Nation can expect to get back $7 in technologically induced economic gain for every single dollar invested in the NASA R. & D. program.

These gains will show in critical areas of the economy, ranging from food production and weather prediction to scientific and medical advances—all spurred by the Nation's investment in NASA's R. & D. programs.

Our vastly superior computers are just one example of how NASA has helped to maintain our economic advantage. It can well be said that instead of a luxury, the space program may be an economic necessity.

However, there is no doubt the NASA programs are costly. Problems associated with the Viking project cannot be repeated. Every dollar appropriated for NASA must have a strong technological and economic justification. We intend to keep that in mind.

BUDGET CONSTRAINTS

For the benefit of some of the new members on the committee, I might say that the NASA budget this year is extremely tight. Inflation has dealt a severe blow to NASA, as it has to all of us. Yet despite the severe funding constraints and the impact of inflation, NASA has made every effort to come up with a budget that will carry forward the approved programs that ought to be done, and that the Congress hopes will be done, within the dollar estimates that NASA presents to us.

The Apollo manned lunar landing program cost about $20 billion. That was remarkably close to NASA's projection of its cost at the very start of the program. NASA stayed within that original estimate. That in itself, I think, was an outstanding management achievement for such a complex task. With that, Dr. Fletcher, we would be delighted to hear you. If you would like to comment on NASA's returns to the economy, you might do that, and then proceed with your statement. We would also be delighted to hear comments from Dr. Low or any of the NASA officials who are here today.

RETURN ON INVESTMENT

Dr. FLETCHER. What you said about the return on investment and the value of technology is absolutely right, Mr. Chairman. For example, it has been estimated that we receive back from the Apollo program $7 for every R. & D. dollar invested. This return on investment has been verified not by NASA but by two different economic groups that studied the program: The first was the Midwest Research Institute in Kansas City, Mo.; the second, more recently, was Chase Econometrics Inc. in New York City.

What I would like to do this morning, Mr. Chairman, with your permission, is to submit my statement for the record, briefly go over the basic elements of the proposed bill, and then ask Dr. George Low to present the highlights of the NASA program.

NO NEW PROGRAM STARTS IN BUDGET REQUEST

Mr. BOLAND. Fine. You don't have any new programs in the fiscal year 1976 budget, do you?

Dr. FLETCHER. There are no new program starts in the fiscal year 1976 budget request or in the transition period budget request.

Mr. BOLAND. We will put the statement in the record, as you have provided it to the committee. Why don't you highlight some of the areas that should be emphasized and discuss whatever problem areas you might have?

GENERAL STATEMENT

Dr. FLETCHER. George Low and I will be happy to do that, Mr. Chairman. I will also submit my prepared statement for the record.

[The statement follows:]

Mr. Chairman and Members of the Subcommittee:

We appreciate the opportunity to be here today to begin your hearings on NASA's budget estimate for FY 1976.

With me here today are Dr. George M. Low, Deputy Administrator; Dr. Rocco A. Petrone, Associate Administrator; Mr. Willis H. Shapley, Associate Deputy Administrator; Mr. Elmer S. Groo, Associate Administrator for Center Operations; and Mr. William E. Lilly, the NASA Comptroller. Also here are the senior NASA officials in charge of our principal offices to respond to your questions in the program areas for which they are responsible.

As indicated on the summary table attached to my statement, NASA's budget estimate for the twelve months of FY 1976 totals $3,539 million. For the three-month transition period to the new fiscal year, the budget request is $958.9 million.

The FY 1976 Budget Plan:

1. Continues the major programs in space and aeronautics approved by Congress in previous years;

2. Contains no new program starts;

3. Reflects reductions and stretch-outs to absorb a substantial portion of the expected inflationary increases in costs, as discussed below;

4. Carries forward in FY 1976 the additional reduction of 300 in civil service employment made by NASA in 1975 as a part of the Administration's overall reduction of 40,000.

In total, NASA's budget for FY 1976 is about $300 million above the FY 1975 Appropriations and budget plan. However, about $200 million is the built-in net increase required for on-going program commitments which was presented to Congress last year with the FY 1975 budget. This means that on an overall basis we have an effective increase of only about $100 million, or 3 percent, much less than the current rate of inflation. The difference between this 3% and the inflation rate of about 9% anticipated in our estimates - some $200 million - is a measure of the degree to which we have had to make reductions and stretch-outs in our FY 1976 programs to stay within the budget constraints.

In summary, then, we are presenting a budget that is lean and constrained, and which has no new program starts.

On a more positive note, the FY 1976 budget will enable us to make important advances in space and aeronautics by proceeding with all of our presently approved major programs generally as planned. Let me mention some points of special interest and significance.

- Space Shuttle development will proceed on the present schedule, pointed to a first manned orbital flight in mid-1979. We will not have to make another disruptive slip in the Shuttle schedule as was necessary under the FY 1974 and FY 1975 budgets. To keep on schedule, however, we had to reduce the technical content of the program in FY 1976. This will increase the technical risk somewhat but within prudent bounds.

- LANDSAT-C (formerly called "ERTS-C"), which was authorized by Congress in FY 1975, will proceed and is scheduled for launch in the fall of 1977. LANDSAT-C will be NASA's third experimental earth resources satellite. It will test improved sensors and complete the experimental demonstrations in crop surveys, water resources management, and many other fields to be undertaken by LANDSAT-2, which was successfully launched on January 22. With LANDSAT-1 and LANDSAT-2 in orbit and LANDSAT-C approved, NASA and the many Federal, State, local and foreign users can now look forward to having LANDSAT data available on a continuous basis for five years, into early 1980.

- Aircraft energy reduction is and will continue as a principal focus in our aeronautics research and technology work. We have identified technologies which have the potential by the end of the next decade to reduce the fuel requirements of commercial jet aircraft by 50 percent. If these advances are achieved by 1985 and incorporated in the number of U.S. commercial aircraft flying today, the savings in crude petroleum requirements would be about one-third of a million barrels per day. With the expected growth in air traffic, the savings for the expanded fleet could approach a million barrels per day in the 1990's.

- Study of the problems of the stratosphere, including the effects of "Freon" and other pollutants that might severely affect the environment, will continue in a coordinated effort. We will bring data and results from many different NASA programs to bear on this important problem. Significant contributions will continue to come from NASA's meteorological and atmospheric satellites, from our sounding rocket, balloon, and high-flying aircraft research programs, and from comparative studies of the atmospheres of other planets coming out of our planetary exploration programs (in which much of the nation's scientific expertise for upper atmosphere studies has been developed).

- Finally, we are entering one of the most active periods in U.S. space flight this year, as NASA projects which have been under development for many years reach their launch dates and as we launch, on a reimbursable basis, a record number of satellites for commercial communications and other domestic, foreign and international organizations. A total of 28 launches are scheduled for calendar year 1975. Of the 28 launches, 18, or 65%, are experimental or operational applications satellites. Also, 14, or 50% of the 28 launches are reimbursable, i.e., paid for by others, not out of NASA's appropriations. These figures illustrate the degree to which the space program is now oriented toward practical applications. They also show that the space age has now arrived at the point where the use of satellites is accepted as a means of providing beneficial services which are economically profitable.

I am also glad to report that NASA has made significant progress in the field of Equal Employment Opportunity (EEO). In 1974 we exceeded, in some cases by a factor of two, the goals we set last winter for hiring and placement of women professionals, minority professionals, and minority non-professionals. While progress will be made more difficult by the additional 300-person reduction in civil service employment we have been required to make in FY 1975, we will shortly be establishing more ambitious EEO goals for the remainder of FY 1975 and for the fifteen month FY 1976, and fully intend to meet them.

The NASA programs--our recent accomplishments, current activities, and future plans -- will be covered in detail as the Subcommittee reviews our FY 1976 budget justifications. I will touch briefly on some of the highlights:

In aeronautics, in addition to the focussed effort on aircraft energy reduction, we are continuing to move ahead on a broad front to develop the technology for improving the capability and performance of civil aircraft. We are also continuing our work with the Department of Defense to improve the performance of military aircraft in each of the areas of NASA's special competence.

We remain very sensitive to the environmental problems of air transportation. Our work on noise and pollution reduction continues.

Airport congestion is one of the most important limiting problems confronting the growth of our air transportation system. We are exploring the technology that could help relieve this congestion. One possibility is the use of aircraft whose lift capability at low speed is improved through the use of propulsion system air flow to provide shorter takeoffs and landings as compared to conventional aircraft.

In cooperation with the military services, we are developing two unique rotor research aircraft. One will be used for advanced helicopter rotor blade research. The other is a "tilt rotor" research aircraft to develop the technology for aircraft that have the capability for vertical flight like a helicopter and the ability to cruise like a conventional propeller-driven aircraft.

We are continuing to augment our programs aimed at providing advanced technology to the general aviation community. The enthusiasm shown by the industry for advances such as the new fuel-saving airfoil we have developed, is very encouraging.

Our aviation safety program is focusing on problems which arise in or near the airport terminal where the majority of fatal aircraft accidents occur. Of particular interest are improved terminal-area aircraft control, and reduction of aircraft trailing wake vortices that can adversely affect aircraft which follow, new materials for reduced fire hazard, and structural and constraint system design to improve the chances of passenger and crew survival in crashes. We shall continue to work closely with the FAA on these matters.

Looking to the more distant future, we are keeping the technological options open for military and civil aeronautics. For example, our research programs related to supersonic and to hypersonic flight continue at appropriately constrained levels, but with sufficient effort to maintain progress and capabilities in these fields.

In space applications, we are experimenting with a wide variety of new ways in which satellites and other technology developed in the space program can be put to practical, beneficial use. The use of satellites for earth resources surveys continue to show special promise. Based on experiments and economic studies to date, we can foresee potential economic benefits to the United States of many hundreds of millions of dollars per year through uses of satellite-collected data -- for inventorying and monitoring crops, for water resources management, range land management, and numerous other uses. Actual benefits are already being realized in the experimental program, but much more work in the experimental demonstrations of operational uses and the detailed assessment of

potential benefits needs to be done. One of the most important demonstrations is our joint "LACIE" crop inventorying experiment with the Department of Agriculture and the National Oceanic and Atmospheric Administration. With LANDSAT-2 now in orbit and functioning well, and the improved LANDSAT-C to be launched in 1977, NASA and the many user agencies working with us will be able to determine how the nation should best take advantage of space capabilities for remote sensing of the earth's resources.

NASA has many other important space applications programs underway. In the field of meteorological satellites, the first "synchronous" meteorological satellite -- SMS-1 -- was launched last year to keep continuous watch on the weather affecting the United States. It has now been joined by SMS-2, launched February 6. Later this year GOES-A, the National Weather Service's first operational satellite of this type, will be placed on station.

Also in the area of weather and climate, this year and next (1975 and 1976) will bring the launch of Nimbus-F (May 1975), the development of the TIROS-N and NIMBUS-B, and further experiments in the international Global Atmospheric Research Program. Nimbus-F is expected to contribute greatly to our understanding of atmospheric processes that influence weather and climate. TIROS-N is the forerunner of a new operational polar orbiting weather satellite system. Nimbus-G will be our first satellite dedicated to the monitoring of pollution.

In other applications areas, the program includes the GEOS-C oceanographic satellite scheduled to be launched this month to demonstrate capabilities to measure the sea surface and sea state on a global basis. We are proceeding with the development of SEASAT, a more capable and sophisticated ocean monitoring satellite to be launched in 1978. Early studies indicate that information derived from SEASAT will be economically beneficial to the shipping and fishing industries and to maritime and shoreline construction projects. SEASAT will also add to our ability to make longer range weather forecasts. LAGEOS (Laser Geodynamic Satellite, which is scheduled for launch in March 1976, will support investigations into motions of large sections of the earth's crust so that we can better understand the mechanics and causes of earthquakes.

In space science, we are proceeding with one of NASA's basic missions--the exploration of space. We are exploring the solar system with spacecraft that can actually go out to the planets, and are penetrating the more distant reaches of the universe with spaceborne telescopes and instruments that can discover and measure new phenomena which are invisible from earth.

In the planetary program, we have had some outstanding scientific and technological successes during the past year. Mariner 10 flew by Venus in February and by Mercury in March and again in September, collecting a wealth of scientific data and pictures of the two planets nearest the sun at each pass. This little spacecraft has already given us two planets for the price of one plus a bonus look at Mercury, and is now heading for a third pass at Mercury later this month; as of now the spacecraft and instruments are still going strong. Also, the first Helios mission, a joint venture between the United States and West Germany, was launched in December 1974 and will study the sun at closer range than any previous spacecraft. In the other direction, away from the sun, Pioneer 11 became our second spacecraft to make closeup observations and measurements of Jupiter and is now on a trajectory to Saturn. Work is proceeding as planned on the next Pioneer and Mariner missions. Mariner-Jupiter-Saturn (MJS), approved in FY 1973, will be launched in 1977 to explore in greater detail the features of those planets observed by Pioneers 10 and 11. Pioneer-Venus, approved last year, will monitor Venus continuously from orbit and send

instrumented probes into its thick atmosphere, to advance our studies of the similarities and differences of the atmospheres of earth and Venus.

Out biggest and most important planetary enterprise is the Viking program to land two unmanned spacecraft on Mars. This is by far the most complex and technologically advanced unmanned space system NASA has ever attempted to develop. If it is successful, it will also give the greatest return. It will give the first detailed analysis of soils and surface conditions on Mars and the first direct search for evidence of life on another planet. To do this, we have to pack into a one-foot cube enough miniaturized equipment to do automatically 225,000,000 miles away work that would require four or five laboratories and a couple of dozen technicians here on earth.

As we have reported to the Committee, we have had serious difficulties in the Viking program during the past year. I am glad to report today that the troublesome technical problems with certain spacecraft and experiment components now seem to be on the way to resolution. Unless unforeseen new problems arise, we are now optimistic that the two Viking spacecraft will be ready for launch in August of this year.

In space astronomy, the objective is to place telescopes and sensing devices in orbit where they can "see" without atmospheric distortions and in wave lengths of light and other radiations that cannot be seen from earth because the atmosphere keeps them out. For example, in a few months we will launch a specialized small satellite called SAS-C to measure X rays from space which cannot be seen from the ground. We are continuing our studies of a possible future Large Space Telescope (LST) in accordance with last year's guidance from the Congress that we explore a lower cost alternative and the possibilities of international participation.

Our major space system development project is, of course, the Space Shuttle. The Space Shuttle is a manned space vehicle that takes off like a rocket, operates in space up to 30 days, lands like an airplane, and can be reused over and over again. It will be used to put satellites in orbit in place of present types of launch vehicles that are expended in each use, and as a manned space laboratory. The result will be less expensive and more routine space operations for all types of applications.

During the past year the Shuttle has definitely moved out of the design phase into hardware fabrication and test. Full scale engine components are being tested. The crew compartment of Orbiter #1 has been built and has now completed pressure tests. Other sections of Orbiter #1 -- the wings and center and aft fuselage sections -- are well along and will soon be arriving at the assembly plant at Palmdale, California. Roll-out of Orbiter #1, prior to approach and landing flight tests, is expected in the fall of 1976. Contracts have been awarded for the Solid Rocket Motors and the External Tank, the other major elements of the Space Shuttle, and work on these elements has begun. At this time we are confident that we will develop the Space Shuttle successfully -- with the performance, on schedule, and within the cost we have specified in advance.

NASA's only manned space flight before the first orbital flight of the Shuttle in 1979 is the Apollo Soyuz Test Project (ASTP) flight this July. Preparations for this first joint US-Soviet space mission are continuing to go well. The Soviet crew has just been in the United States for the final joint-crew training sessions in this country; in April the final joint training in the USSR will begin. This program is significant not only for the development and testing of a universal space docking system and for the scientific experiments that will be conducted, but is also an experiment in how we can work with the Soviets on a complex project.

In energy research and development we are continuing our efforts of exploring ways in which aeronautical and space technology can be applied to meet the nation's energy problems. We are also undertaking, with transferred funds, energy research and development projects for which other agencies have the primary responsibility.

NASA was given specific responsibilities in two pieces of legislation enacted by Congress late last year. Under the Solar Heating and Cooling Demonstration Act of 1974, NASA and HUD have completed and sent to the Congress a demonstration plan for residential dwellings as contemplated in the Act. A demonstration plan for commercial applications has been drafted as have the requests for proposals from industry and small business required to implement the Act. NASA's responsibilities have now been formally transferred to the new Energy Research and Development Agency (ERDA) in accordance with the law; however, the Administrator of ERDA has indicated his desire for continued involvement of NASA laboratories in various aspects of solar research and development. Under the Geothermal Energy Research, Development and Demonstration Act of 1974, NASA, in cooperation with ERDA, is working to help define a comprehensive national plan for the effective development and utilization of geothermal resources on a national and regional basis.

We are also working with ERDA on other energy projects such as low pollution and high fuel economy, gas turbines for automobiles, the harnessing of wind energy, the development of low cost solar cells to convert sunlight into electricity (a technique we used in many of our spacecraft), and a comparative study of the many ways to convert coal or coal-derived fuels into useful power in central power stations. We are cooperating fully with the newly established ERDA and are prepared to carry on projects for them with transferred funds.

In our projects applying space and aeronautical technology to energy problems, we are working, for example, on the development of a high efficiency, low pollution internal combustion engine (a project started in an attempt to find ways to make aircraft engines more efficient, but applicable to automobile engines as well). This concept is referred to as "hydrogen injection" and is producing promising results. We are also working on integrated utility system technology which is a projection of our experience in providing life support systems for our manned spacecraft. And, we are studying the technical and economic feasibility of providing electrical power to earth from large satellite solar power stations.

In conclusion, Mr. Chairman, let me emphasize that NASA's aeronautics and space programs, and especially the advanced technology we are developing, are indeed relevant to today's world and today's problems. More than ever before, the many complex problems which face the world -- in energy, food, transportation, and pollution control, for example -- require solutions in which new and innovative technology will have to be one of the major elements. The long-term answer to the problem of inflation is increased productivity; this too depends on advances in technology. If the Subcommittee wishes, we can describe many examples of ways in which NASA programs are directly and indirectly helping solve today's and tomorrow's problems.

We look forward to discussing with you the details of our aeronautics and space programs and how they contribute to the advancement of knowledge and technology, and thereby to a better world.

Mr. Chairman, this concludes my prepared statement.

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Attachment:

Summary of NASA FY 1976 Budget

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FY 1976 BUDGET
(Thousands of Dollars)

Research and Development:	FY 1974	FY 1975	FY 1976	Transition Period
MANNED SPACE FLIGHT	999,900	1,110,300	1,414,600	376,600
Space shuttle	475,000	797,500	1,206,000	321,000
Space flight operations	523,400	311,300	207,100	55,100
Advanced missions	1,500	1,500	1,500	500
SPACE SCIENCE	664,482	542,815	582,600	160,300
Physics and astronomy	94,000	136,315	155,800	46,600
Lunar and planetary exploration	392,482	266,000	259,900	73,300
Launch vehicle procurement	178,000	140,500	166,900	40,400
APPLICATIONS	159,000	174,500	175,030	54,700
Space applications	159,000	174,500	175,030	54,700
AERONAUTICS AND SPACE TECHNOLOGY	234,307	237,765	250,250	69,100
Aeronautical research and technology	168,000	166,400	175,350	46,800
Space and nuclear research and technology	66,307	71,365	74,900	22,300
ENERGY PROGRAMS	4,693	4,435	5,900	1,500
Energy technology applications	4.693	4,435	5,900	1,500
TRACKING AND DATA ACQUISITION	244,000	248,000	243,000	66,400
TECHNOLOGY UTILIZATION	4,500	5,500	7,000	2,000
Total, Research and Development	2,310,882	2,323,315	2,678,380	730,600
Construction of Facilities	101,100	142,655	84,620	14,500
Research and Program Management	743,968	765,175	776,000	213,800
TOTAL, BUDGET PLANS	3,155,950	3,231,145	3,539,000	958,900
TOTAL APPROPRIATIONS	3,039,700	3,231,145	3,539,000	958,900

IMPACT OF INFLATION

Dr. FLETCHER. You mentioned the amounts we are asking for in our fiscal year 1976 and transition period budget requests.

You also mentioned that there are no new program starts. The fiscal year 1976 budget limitations result in a severely constrained program, and I will have more to say about that subject later. In addition to no new program starts, we have had to absorb the major portion of inflation during the past year. I can illustrate this impact by indicating that although the fiscal year 1976 budget request is about $300 million above our fiscal year 1975 budget estimate, about $200 million of that increase was already projected last year as requirements to carry on the currently approved programs. As a result, we have an effective increase of only 3 percent, which is far less than the approximately 9-percent increase in inflation we are experiencing.

The difference between those two numbers indicates the amount we have had to cut back. I'm sorry to say that this cutback has cost about 7,500 jobs below the number projected last year. So the fiscal year 1976 budget request represents a severely constrained program, but despite all that, there is some very positive progress that we can point to.

PRINCIPAL PROGRAMS

In the first place, the Space Shuttle is on schedule, leading to the first manned orbital flight in mid-1979. We did have to cut out about $45 million from the fiscal year 1976 Space Shuttle R. & D. effort to keep within the budget limitations. We have made cuts which, I think, are within prudent bounds. The adjustments in no way compromise safety or performance but they do increase the technical risk somewhat. However, the Space Shuttle development is progressing well, and barring unforeseen problems, we are confident that we can meet our commitment.

Landsat-C, approved by the Congress last year, is also in our program. Landsat-C is a project which is a continuation of the previous two Earth resources satellites. Landsats 1 and 2, with some significant improvements. Landsat-C will have some new instruments, particularly a high resolution camera system and a scanning system with a fifth channel for observing thermal effects on Earth.

Although it is not a new program, Mr. Chairman, we have reoriented some of our "old" programs to deal with problems of the upper atmosphere. There have been severe theoretical predictions with regard to contamination of the upper atmosphere by various potential sources: emission from supersonic-type aircraft and, more recently, effects of "Freon" and other pollutants. We have reoriented our program dealing with satellites, sounding rockets, balloons, and airborne research, as well as our planetary program, to provide a focus for studying the effects of potential pollutants on the upper atmosphere.

Despite the severe budget constraints, we have a record number of launches planned for this calendar year—28. As a measure of the space program "coming of age," most of these launches will be paid for by other people. NASA will be reimbursed. Dr. Low will go through the 1975 launch schedule for you in some depth.

EQUAL OPPORTUNITY PROGRESS

We have made considerable progress in our equal employment opportunity program. Last year, as you recall, we set some ambitious

goals for hiring of women professionals, minority professionals, and minority nonprofessionals. We not only met those goals, but we exceeded them by a factor of two. This year we plan to set even higher goals than last year. So the equal opportunity program is in full gear. I am proud to say we have made considerable progress, despite the fact that we were required to reduce our fiscal year 1975 civil service level by an additional 300. We have set even more ambitious equal opportunity goals for 1975 and we fully intend to meet and, hopefully, surpass these goals.

IMPORTANCE OF INNOVATION AND NEW TECHNOLOGY

Before George Low begins, let me emphasize a point that you made earlier and that we have made in precious hearings: Innovation and new technology, I believe, are absolutely essential to the solutions of many of the complex problems facing not only our Nation but the whole world. These pressing problems, such as energy, food, transportation, and pollution, must be solved by the application of appropriate technology. Lately, even the long-term answer to inflation is believed to be increased productivity. The answers depend to an extremely critical degree, on the development of new technology. It is with these factors in mind that I would hope our fiscal year 1976 request would be assessed.

That is a summary of my prepared statement, Mr. Chairman.

Mr. BOLAND. Thank you, Dr. Fletcher.

May I introduce to the NASA witnesses Mr. Robert Traxler, who is a Member from the State of Michigan. I presume, as I said, that some of you have visited with him.

SPACE SHUTTLE DEVELOPMENT COST

There are some programs in NASA that are very costly. The Space Shuttle, of course, is a program that carries the highest dollar figure for this fiscal year 1976 request. The fiscal year 1976 budget request for the Space Shuttle program is $1,206 million. Does NASA expect the Space Shuttle to be operational in 1980?

Dr. LOW. Yes, sir, and the first manned orbital flight of the Shuttle is planned for mid-1979. The development efforts are on schedule.

Mr. BOLAND. When the Space Shuttle was determined by the administration to be a national goal, just as the Apollo program was when President Kennedy made the recommendation that we ought to go to the Moon, there had to be a recommendation made by the administration with reference to the Space Shuttle because that development program is going to cost $5,200 million. Is that the cost estimate?

Dr. FLETCHER. Yes. The cost estimate for the design development, test and evaluation, including procurement of two orbiters, is $5,200 million in 1971 dollars.

Mr. BOLAND. What is the total cost?

Mr. LILLY. The total D.D.T. & E. cost estimate is $5,200 million in 1971 dollars. In the dollars of the fiscal year 1976 budget, the estimate is $6,350 million. If inflation continues at a nominal number, at about 7 percent, it would be about $6,900 million. In addition the estimate for the initial facilities is $300 million in 1971 dollars.

TRANSITION PERIOD REQUEST

Mr. BOLAND The NASA budget request, as I indicated, also carries $958,900,000 for the transitional period which will occur from July 1 to September 30, 1976, because of the change in the fiscal year, pursuant to the Congressional Budget and Impoundment Control Act of 1974. The new fiscal year will run from October 1 to September 30, beginning in 1976.

Dr. Low, we are delighted to have you with us. May I say that Dr. Low has been with the program for how many years now?

Dr. LOW. I have been with NASA since the agency was formed in 1958. Before that I was with the National Advisory Committee for Aeronautics, the agency which formed the nucleus for NASA.

NASA PROGRAM HIGHLIGHTS

Mr. BOLAND For those who don't know Dr. Low, let me say I know of no one in the Government who has a better knowledge of the operations of his particular agency. He has grown up with the agency over the years and is one of the most dependable public servants I am aware of in my long service in the Congress.

We are delighted to have you, Dr. Low. Perhaps when you are going through your presentation, you can point out to the new committee members key points about these programs. I'm sure they would like to have the benefit of your thought.

Dr. LOW. Thank you, Mr. Chairman. With your permission, I will go through the details of the NASA program.

NASA'S 1975 LAUNCH SCHEDULE HIGHEST SINCE 1966

Could I have the first slide, please (fig. 1.)?

NASA 1975 LAUNCH SCHEDULE

	J	F	M	A	M	J	J	A	S	O	N	D
EARTH RESOURCES	▲											
WEATHER		▲			△	△					△	
OCEANOGRAPHIC			△									
EXPERIMENTAL COMMUNICATIONS									△			△
DOMESTIC COMMUNICATIONS			△									△△
INTERNATIONAL COMMUNICATIONS		✗			△		△			△		
MARITIME COMMUNICATIONS				△			△					
NAVIGATION												△
ATMOSPHERIC RESEARCH									△		△	△
SOLAR OBSERVATION					△							
MARS LANDING								△△				
ASTRONOMY & OTHER SCIENCE					△		△△					
APOLLO/SOYUZ - US/USSR							△					

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Figure 1

As Dr. Fletcher pointed out, in 1975 we have a total of 28 launches by NASA in the space program. Twenty-eight is the highest number of launches since 1966. After 1966, we came down considerably. Our 1975 launch schedule averages about two per month.

1975 LAUNCH STATISTSCS

I have divided these launches into three basic categories: applications, such as earth resources, weather, ocean, and communications satellites, with a total of 18 of these launches in 1975; science with a total of 9 scientific satellites in 1975; and manned international with one first, pioneering joint mission with the Soviet Union, called the Apollo-Soyuz test project which is coming up in July of this year (fig. 2).

NASA 1975 LAUNCH STATISTICS

APPLICATIONS	18	REIMBURSED	14
SCIENCE	9	COOPERATIVE	1
MANNED INT'L	1		
	28		

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Figure 2

APPLICATIONS LAUNCHES

What is different about this year is that 18 of those 28 launches, almost two-thirds, are in the field we call "applications." Now by applications, I mean missions dealing with earth resources, weather, pollution monitoring, ocean dynamics, and communications. They are applications of space for the benefit of people down on-earth.

We are paid for launch services that we perform for others. Some of the satellites you see here, such as domestic communication satellites, are used by companies like Western Union or RCA because it is more efficient and cheaper to communicate by using space than by laying land lines. NASA provides the launch services to them and they fully reimburse us.

Of the 28 launches in 1975, half or 14 are reimbursed and funds do not need to be appropriated for them.

LAUNCH VEHICLE REIMBURSEMENTS ANTICIPATED IN FISCAL YEARS 1975 AND 1976

Mr. BOLAND. What would be the cost of them?

Dr. LOW. Mr. Lilly.

Mr. LILLY. Mr. Chairman, in fiscal year 1975 we anticipate reimbursements for launch vehicles and launch services of $137.2 million from non-Federal sources and $12.2 million from Federal sources. In fiscal year 1976, we anticipate about $108.5 million from non-Federal sources and about $12.5 million from Federal sources on a reimbursable basis.

Dr. FLETCHER. I might add that those estimates only include the launch vehicles and launch services. Of course, the users pay for their own spacecraft. The total number of reimbursable orders would be at least double that and maybe triple.

Mr. BOLAND. But the reimbursement of NASA for the launch vehicles and services is the amount that bill gave?

Dr. LOW. Yes.

Mr. TALCOTT. Is the dollar value about half as well as the number of launches or do they reimburse us for the less expensive shots and are we paying for the expensive ones?

Dr. LOW. They are reimbursing us for whatever launch vehicles we procure and the launch services we provide. For example, the weather satellite launches that we carry out for the Weather Service are on a Delta launch vehicle, which costs on the order of $10 million. The international communication satellites, the Intelsats for Comsat, are geneally launched on an Atlas Centaur, which costs on the order of $20,000 million. We are being reimbursed for launch vehicles and services provided to these users.

LANDSAT–2 AND SMS–2 SUCCESSFULLY LAUNCHED

So far this year, we have had two successful launches; one earth resources satellite LANDSAT–2, and one weather satellite, the Synchronous Meteorological Satellite–2. Unfortunately, an unsuccessful launch occurred last week when we launched a communications satellite for Comsat. There was a failure in the Atlas booster. It was a total loss. However, Comsat has to bear the loss, as they would have benefited from the services provided.

Unfortunate as the failure was, there was no cost to the Government.

EARTH RESOURCES SURVEY SATELLITES

Mr. BOLAND. I wonder if you would, George, indicate to the committee what the earth resources satellite does.

Dr. LOW. Mr. Chairman, I will briefly cover it now. I will have more to say about it later with a few pictures.

Basically, an earth resources satellite is a satellite that looks down at the earth and can determine, among other things, crop acreage, and agricultural yield. Hopefully we will be able to use it to collect data on agricultural production in terms of bushels per acre and how many acres of a crop, such as wheat, are growing around the world.

NASA OBJECTIVES

What is NASA and what are our objectives (fig. 3)?

I like to think of NASA's role in terms of three basic objectives: To explore the universe in order to increase our understanding of its

NASA OBJECTIVES

- EXPLORE - TO INCREASE UNDERSTANDING
- APPLY - TO IMPROVE QUALITY OF LIFE
  - FROM SPACE
  - ON EARTH
- AERONAUTICS - MORE EFFICIENT (LESS ENERGY-CONSUMING) FLIGHTS

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Figure 3

past, present, and future and particulary man's place in the universe and to apply what we learn in space and from space in order to improve the quality of life here on the earth.

SOLAR HEATING AND COOLING

We are applying the returns from space technology and operations in terms of better weather forecasts, cheaper communications and better management of the Earth's resources.

We also apply our space technology to help solve problems here on Earth. This, Mr. Chairman, is where some of the "seven to one" dollar payback that you discussed earlier comes in. One example stemmed from the Skylab program. We had to develop a special coating to keep the Skylab space station just cold enough and just warm enough against the rays of the sun. This same coating is being applied by the people at one of our field centers to the coating on solar panels used to heat or cool a home. It turns out that this coating originally developed for Skylab, is a much more efficient coating than any yet devised, and it is being applied here on Earth to make it possible to use the sun's rays to heat a home and thereby save fossil fuels.

AERONAUTICS FUEL SAVINGS

Of course, we are the National Aeronautics and Space Administration. We do the civilian research in aeronautics for this Nation. Much of the effort today in our aeronautics program is devoted to research and technology on savings of fuel, cutting down the amount of fuel consumed by the commercial fleet of aircraft.

Now I will use a picture to try to explain briefly why we go into space, why we have to go into space to explore and to see what is out there (fig. 4).

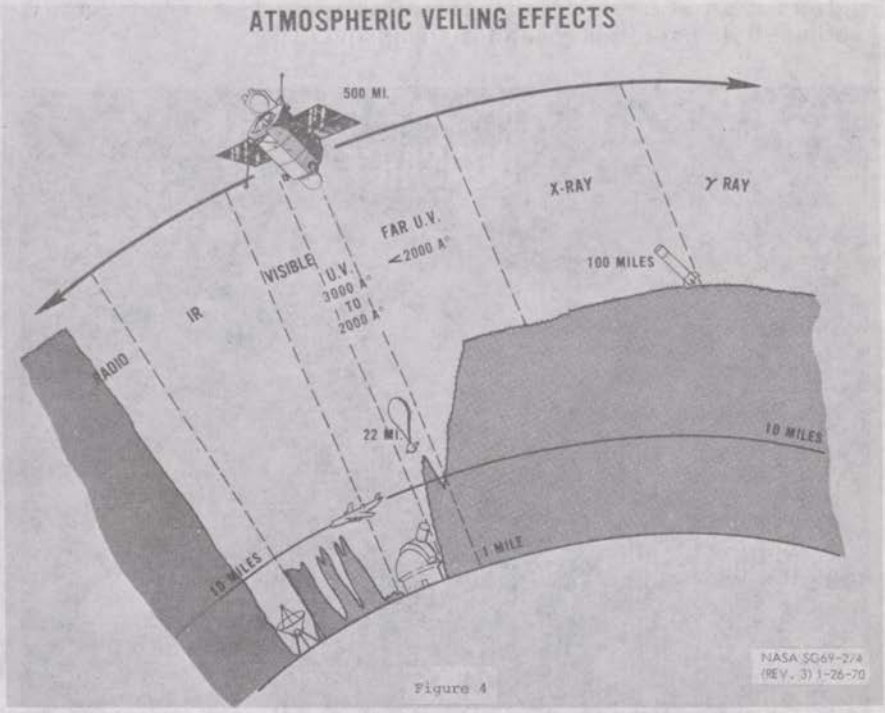


Figure 4

The main point I want to make is that everything out in space—the sun, the planets, the stars, and the space between—sends signals to us. These signals come to us not only in a light we can see, the visible light, but also in invisible X-rays, gamma rays, and radio waves. Yet most of these signals are blanketed out by the atmosphere. For example, many stars send signals in ultraviolet light. Luckily for us, the atmosphere, which is shown in a dark gray here, filters out most of this ultraviolet light, or we would burn to a crisp.

To understand what makes a star tick, we have to go above the blanket of the atmosphere to look at the star. We see things in this very narrow band which we call visible light—red, orange, yellow, green, et cetera. To the left of that region, we have longer waves, such as infrared and radio waves. Some of the radio waves penetrate the ocean of atmosphere that surrounds us. To the right, we have shorter waves, such as ultraviolet, X-rays, and gamma rays.

We are sitting at the bottom of this blanket of the atmosphere. We try to look through this blanket, but we see very little, only through a narrow slit of visible light. To gain a better understanding of the universe around us, we have to rise above the Earth's atmosphere. We can do this by satellites in earth orbit, which can look out with telescopes or by automated spacecraft that can fly by planets and travel through space. Automated spacecraft have gone to the "near" planets like Venus, Mercury, Mars, and Jupiter.

HIGH ENERGY SOURCES

When we extend our "eyes" above the atmospheric veil of Earth, we see strange phenomena with strange names like quasars and pulsars and black holes. We do not understand these phenomena very well, but we do know that they are extremely important and exciting.

Here is an artist's rendition of a quasar which is very far away, perhaps billions of light-years away (fig. 5).

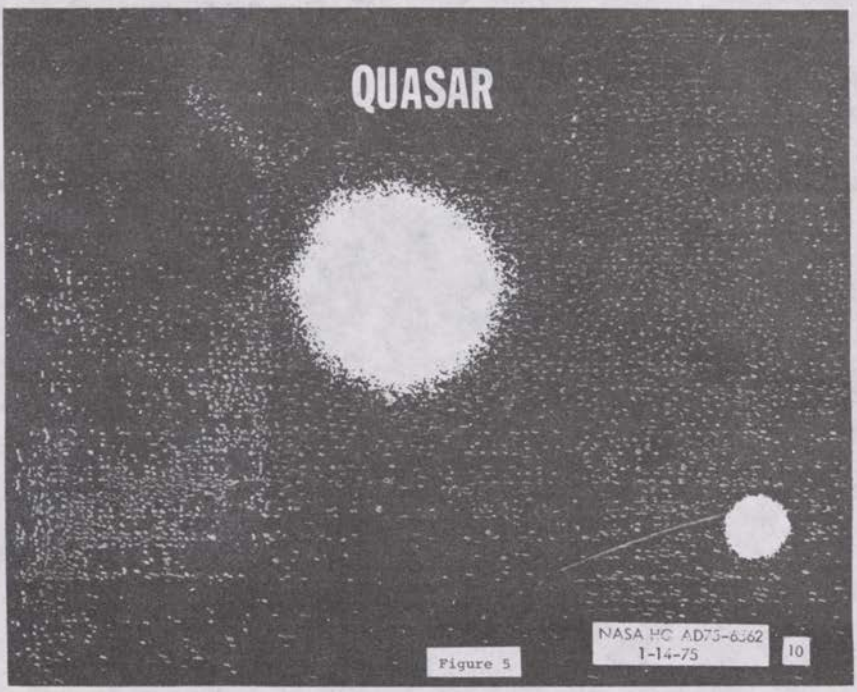


Figure 5

A quasar gives out incredibly enormous amounts of energy; there is 50 trillion times as much energy in a single quasar than in our own sun—fifty thousand, thousand, thousand times as much energy as our own sun.

In order to study energy phenomena such as quasars, we have to look at them in this whole spectrum of invisible and visible light, and we can only do this by getting above the obscuring effects of our atmosphere.

Why is it important? It is as important to study all these strange energy sources now, perhaps even more so, as it was years ago to study the sun, which led us to an understanding of nuclear processes. We still need to increase our understanding of the fusion process, and

we need to study phenomena like quasars. If we are going to solve our long-term energy problems, we are going to have to gain a basic understanding of what makes the universe tick, of what is out there. This is particularly important in terms of these very, very high energy sources that we cannot explain with today's knowledge. We are adding to the fundamental store of knowledge by sending spacecraft above the atmosphere to lookout and study energy sources such as the quasars.

MANNED SPACE FLIGHT PROGRAM HIGHLIGHTS

Let's move on to our various programs, starting with manned space flight (fig. 6).

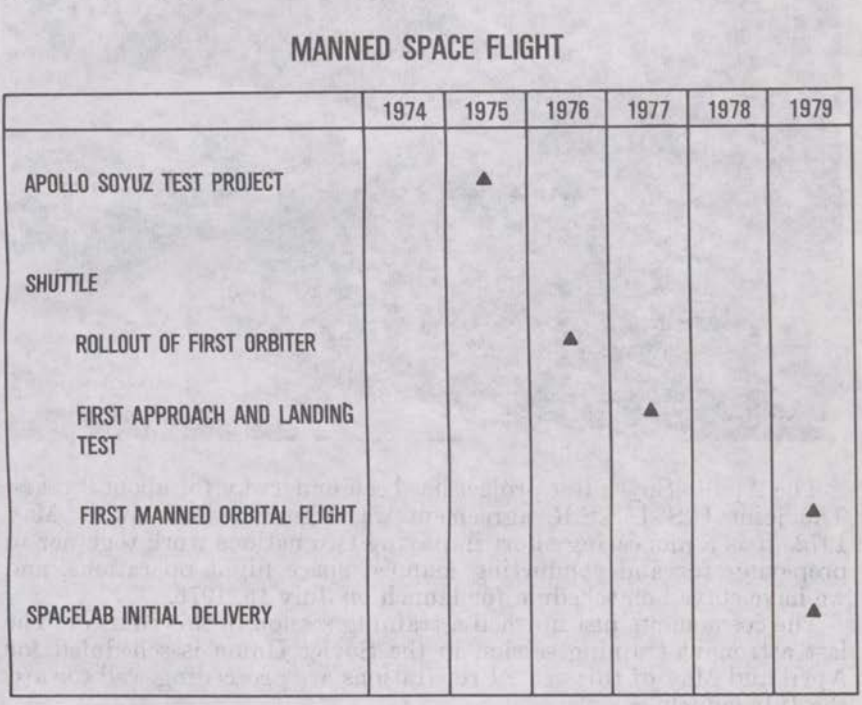
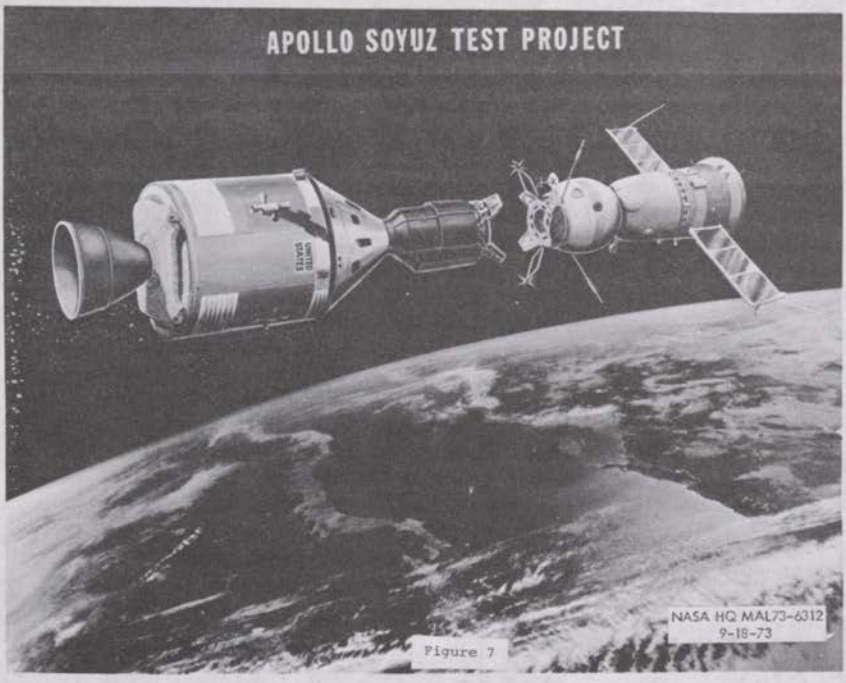


Figure 6

APOLLO SOYUZ TEST PROJECT

The next manned space flight, and the only one left using Apollo-type hardware, is a cooperative effort with the Soviets, called the Apollo-Soyuz test project. It will be an Earth orbital mission and will be the first international manned space flight. We will launch the three-man Apollo spacecraft and they will launch one of their

two-man Soyuz spacecraft. We will meet in Earth orbit, rendezvous, and dock; exchange crews; and conduct joint scientific experiments (fig. 7).



The Apollo-Soyuz test project has been underway for about 3 years. The joint U.S.-U.S.S.R. agreement was signed in Moscow in May 1972. It is a pioneering effort in having two nations work together in preparing for and conducting manned space flight operations, and we have stayed on schedule for launch on July 15, 1975.

The cosmonauts just finished a training session in this country. The last astronaut training session in the Soviet Union is scheduled for April and May of this year. Preparations are proceeding well toward the July launch.

SPACE SHUTTLE

Let's turn now to the Space Shuttle. The chairman has already mentioned that the major program in NASA today is the Space Shuttle (fig. 8).

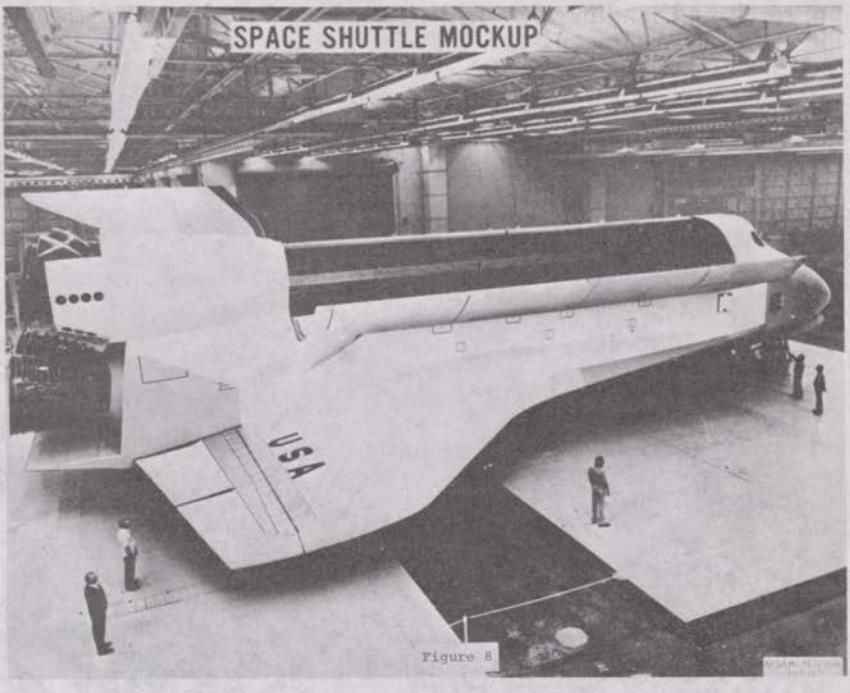


Figure 8

The Space Shuttle is going to replace the expendable launch vehicles that we use today—Atlas, Delta, Centaurs, and so forth. The Shuttle will be launched into orbit like a rocket. Once the Shuttle is in orbit, these huge doors can be opened. Its cargo bay is 60 feet long and 15 feet in diameter. The Shuttle can be used to put payloads into the Earth orbit or send to higher orbits all the satellites we talked about before—weather, Earth resources, communications, and scientific satellites. The Space Shuttle will have a major advantage over the vehicles we have available today.

With the Shuttle, we will no longer have to "throw away" payloads. It will allow us for the first time to bring them back and use them over and over. The Shuttle vehicle itself, of course, will also be used repeatedly. We are talking about building only five of these Shuttle orbiters to take care of the entire civilian and military space program.

The reusable Space Shuttle will be the new economical and versatile way of getting into space and coming back to Earth. We call it the DC 3 of the Space Age because it will make it far more efficient and economical to go to and from space on a routine basis, and will reduce the cost of space flight and the cost of payloads.

SHUTTLE DEVELOPMENT PROGRESS

The Shuttle development, which began in 1972, is progressing well. The first orbiter will "roll out" in the fall of 1976. In the last part of 1977, we will conduct the first approach and landing test. The orbiter will be carried piggyback on a large 747 airplane. We will take it up to an altitude of about 25,000 feet, release it, and let it land. These

approach and landing tests will be conducted to determine the orbiter's landing characteristics.

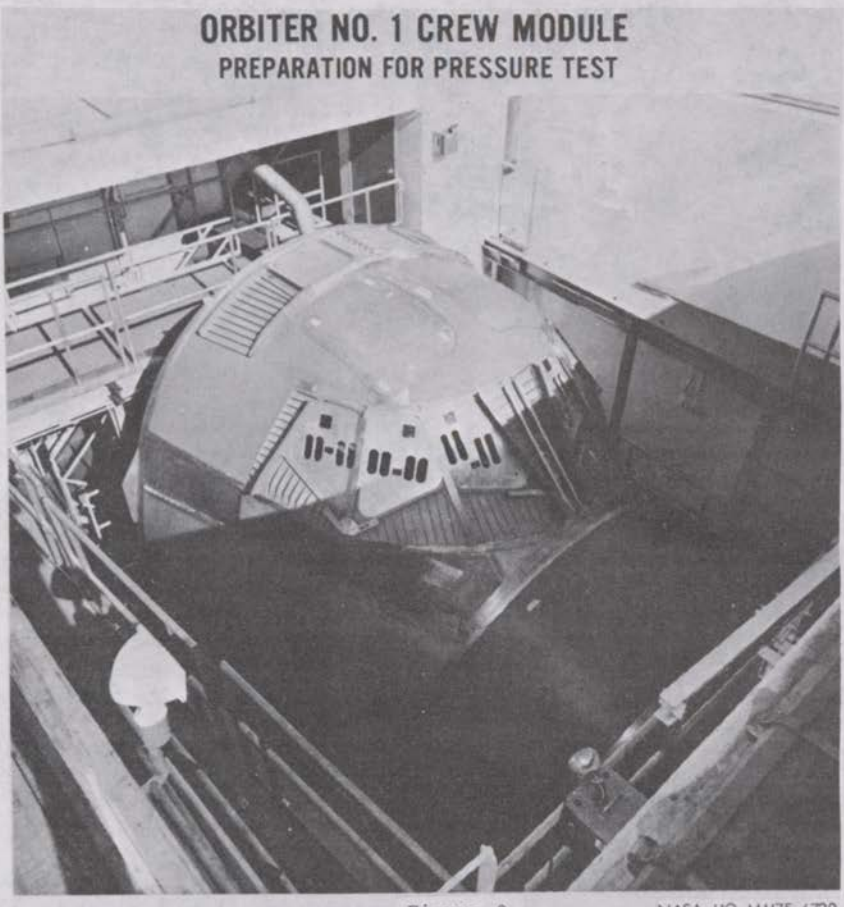


Figure 9 NASA HQ MH75-6720 1-21-75

Once those tests have been completed, we will proceed with the first manned orbital flight, which is scheduled for midcalendar year 1979. Just to show you that we have progressed beyond the mockup shown in figure 8, the next picture shows the first piece of flight hardware (fig. 9).

This is the nose section—the crew module—of the first orbiter in a test cell at the Rockwell International plant in Downey, Calif. Other parts of the orbiter are being built at various plants across the country. This summer, all these parts—wings, tail, midfuselage, and so forth—will be delivered, and the assembly operations will begin at Palmdale, Calif.

MAJOR SHUTTLE ELEMENTS

Mr. BOLAND. If there are any questions while Dr. Low is explaining this, please feel free to ask them. It might give you a better understanding when we start to get into the detailed budget justifications.

I understand we all know all about this, but if there are any questions, please feel free to ask. Perhaps you would like to summarize the major elements, Dr. Low.

Dr. Low. The orbiter is the airplanelike feature of the Space Shuttle system.

We will also be talking in the ensuing hearings about the twin solid rocket boosters, which are the two outrigger-type devices attached to either side of the large tank. Those boosters are used to give the orbiter the initial lift out of the Earth's atmosphere. These solid rocket boosters are dropped off and land by parachute in the ocean. They are recovered and brought back for refurbishment and reuse.

The big tank in the middle of the two solid rocket boosters is a gas tank containing the hydrogen and oxygen propellants for the orbiter's main engines. It has all the propellants needed to get the orbiter into orbit. It burns that through the three main engines located in the tail of the orbiter itself. So those are the four major Shuttle elements: the orbiter; its main engines; the tank; and the two solid rocket boosters.

EXTERNAL TANK COST

Mr. Traxler. Is the tank recoverable?

Dr. Low. Mr. Traxler, the tank is the only Shuttle item which is not recoverable. The tank goes almost into orbit and is jettisoned back into a remote, predetermined ocean region.

Mr. Traxler. What is its cost?

Dr. Low. Our goal is down between $1 million and $2 million per copy in large quantities. The Shuttle cost per flight estimate is $10.5 million in 1971 dollars. An Atlas Centaur, which is an expendable launch vehicle, costs about $20 million. The Shuttle will have a weight-lifting capacity four or five times that of the Atlas Centaur. And, as I mentioned, the Shuttle will be used for servicing and retrieval of payloads.

In effect, we will get a factor of 10 improvement on weight-lifting capacity by using the Space Shuttle vehicle, including the cost of the tank, instead of using the Atlas Centaur.

SHUTTLE MAIN ENGINES RECOVERABLE

Mr. Young. You say that the tank is not recoverable. How about the main engines?

Dr. Low. The engines are attached to the orbiter. The engines can be recovered and reused. These engines are the big main propulsion engines which are affixed to the tail end of the orbiter. There are huge pipes which feed the propellants from the tank into the orbiter's engines.

SPACELAB TO BE FUNDED AND DEVELOPED BY ESRO

I want to make one more point here before I go on. The Spacelab will be the main laboratory part of the Shuttle. The Spacelab will be a versatile laboratory, which fits into the Shuttle's cargo bay. It is being built by the Europeans with their own funds. The European Space Research Organization is spending about $420 million of their own money to develop and build the first Spacelab as an adjunct to the Space Shuttle vehicle. The Spacelab is an important part of our international program. The Spacelab will provide a multipurpose lab-

oratory which can be equipped for various purposes and will allow scientists and technicians to conduct experiments in Earth orbit.

Mr. BOLAND. Which European nations are developing and building it?

Dr. Low. Ten member nations of the European Space Research Organization are participating. Do you have a list of the countries, Mr. Yardley?

Mr. YARDLEY. We will be glad to list them for the record. There are 10 European countries providing the funding.

[The information follows:]

The member nations of ESRO which are participating in the Spacelab program and their percentages of involvement are as follows: Germany, 53.3 percent; Italy, 18 percent; France, 10 percent; United Kingdom, 6.3 percent; Belgium, 4.2 percent; Spain, 2.8 percent; the Netherlands, 2.1 percent; Denmark, 1.5 percent; and Switzerland, 1 percent. A 10th nation, Austria, although not a member of ESRO, is participating to the extent of 0.8 percent.

Dr. Low. As I mentioned, the Europeans are providing the funds for the Spacelab development. Some of their money is being spent in this country.

SPACE SCIENCE PROGRAM HIGHLIGHTS

Let me move on to Science, highlighting some of our major lunar and planetary exploration and physics and astronomy flight projects. This is where we go out into space, look out into space or go to the planets with automated, unmanned spacecraft (fig. 10).

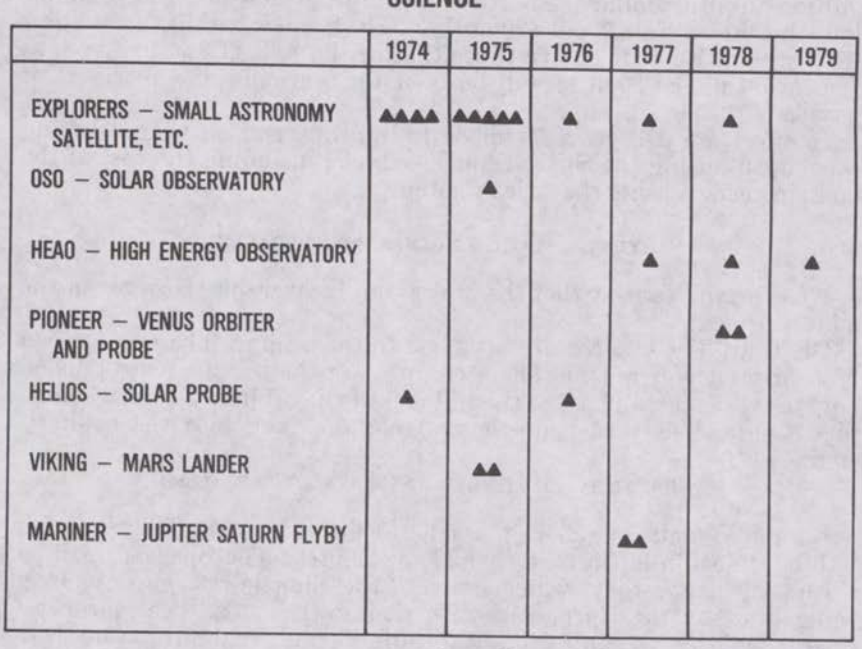


Figure 10

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In the past year, a mariner spacecraft conducted "fly-by" observations of Venus. This is a picture of Venus, our closest neighbor planet, taken in the ultraviolet light region (fig. 11).

I wanted to show this picture because interestingly enough, these investigations of Venus cast light on the ozone-Freon problem Dr. Fletcher described.

ATMOSPHERIC STUDIES

Our concern about our own planet's atmosphere, including the stratosphere, actually stemmed from scientific investigations of Venus. Planetary scientists who were studying the atmosphere of Venus started asking questions about our own Earth's atmosphere and said that we may have a problem here with the depletion of ozone which affects the penetration of ultraviolet rays. This is one major example of how the planetary exploration program allowed us to get a head-start in studying what may be a potentially dangerous problem in atmospheric effects.

PIONEER PROBES TO OUTER PLANETS

During the past year, our Pioneer spacecraft flew past the planet Jupiter which is the first of the so-called outer planets beyond Mars and the Asteroid Belts (fig. 12).

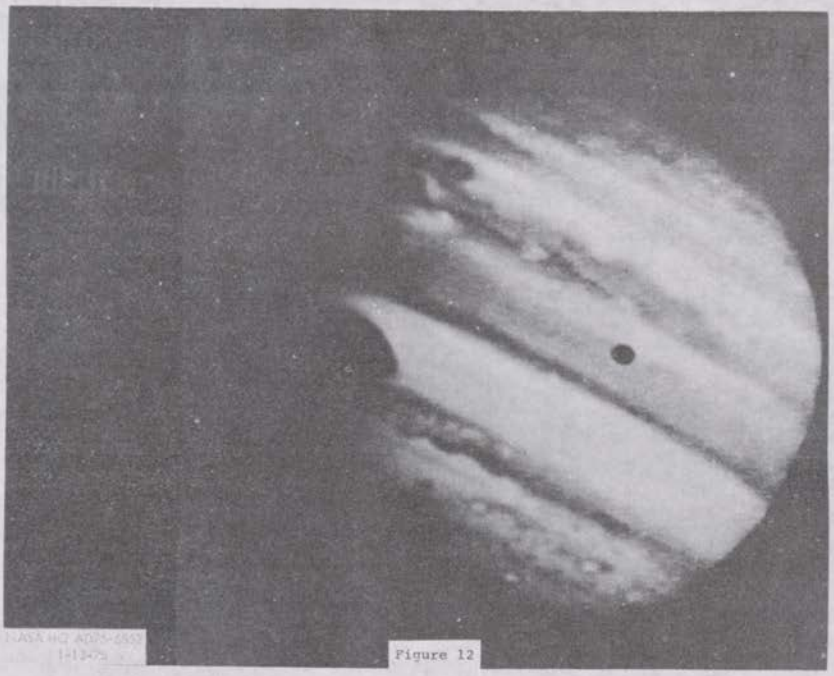


Figure 12

At the time this dramatic picture was taken by the Pioneer space probe which flew by the planet, Jupiter was 500 million miles from the Earth. You can see a shadow of one of the giant planet Jupiter's moons. The red spot is one of the mysteries of Jupiter's atmosphere.

TECHNOLOGY FROM PLANETARY PROGRAMS

Rather than just talk about the science returns, I would like to make a point about the kind of technology we needed to develop. This picture was sent back with a transmitter with power of only 8 watts. Because this fact always amazes me, I brought along a 7-watt light bulb. The power of the transmitter that sent back this picture was about equivalent to the power that it would take to light this very small bulb. Yet it sent back this picture through over 500 million miles of space.

A downtown Washington television station has the power of up to 300,000 watts, compared with this 8-watt transmitter.

We do not do this because we like to do things the hard way. We do it because we have to. We cannot afford the weight that would be necessary to transmit with a higher power. I should inject that my comparison with the downtown television station is not totally fair because it takes more time to transmit this picture than it does to transmit the noninstantaneous picture to your home.

However, it illustrates the type of technology we have achieved in the space program that shows us how to meet these challenges. This technology feeds back into domestic commercial developments. It explains part of the seven-to-one payback from the money spent on space, which the chairman mentioned at the beginning of this hearing.

Mr. TALCOTT. What is the light source of this shadow—our Sun?

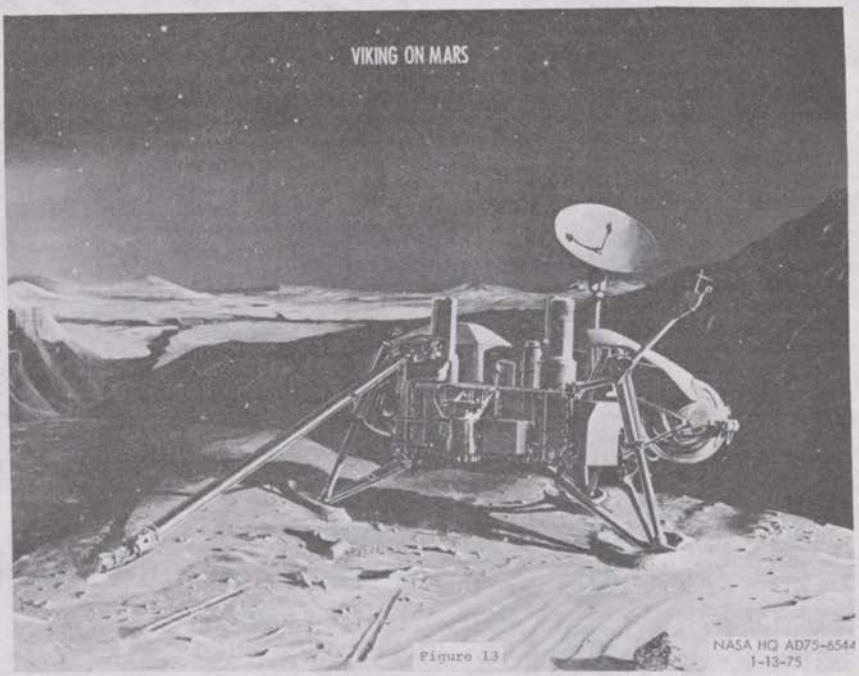
Dr. LOW. Yes.

Mr. YOUNG. How long does it take to transmit that photograph with the 8-watt power?

Dr. LOW. On the order of 30 minutes.

VIKING PROGRAM PLANS AND OBJECTIVES

The most complex, large-scale unmanned space project that we have underway is the Viking Mars landing. This is an artist's rendition of what Viking will look like when it is sitting on Mars (fig. 13).



The Viking launches will take place in August of this year. The spacecraft will not reach Mars until July of next year and will land on Mars. The Viking spacecraft which lands on the surface of Mars will send back information about the planet's surface, temperature, weather, and characteristics. In addition, there is an extremely compact, sophisticated biological lab in the lander spacecraft designed to detect life forms, if there were, are, or could be any on Mars. If there is evidence of life forms, it will be the first time that we have found life in our solar system.

TOTAL COST OF VIKING

Mr. BOLAND. What is the total cost of the Viking program?

Dr. Low. The total cost of Viking, including the launch vehicles, will be on the order of $1 billion.

Mr. Boland. And what have we spent to date?

Dr. Low. Through February 1975, we have obligated approximately $900 million, including the launch vehicles.

I should mention that last year we reported to the committee that we had encountered technical problems with several parts of the program, particularly the computer and biological lab. Essentially all of these problems have now been resolved and both of the spacecraft have already been delivered to Kennedy Space Center to be prepared for the launches.

ORBITING SOLAR OBSERVATORY TO STUDY SUN AND EARTH'S STRATOSPHERE

We are also studying the Sun. This is a picture of the Sun taken during a Skylab mission. It shows some of the detail of the Sun's fine structure (fig. 14).

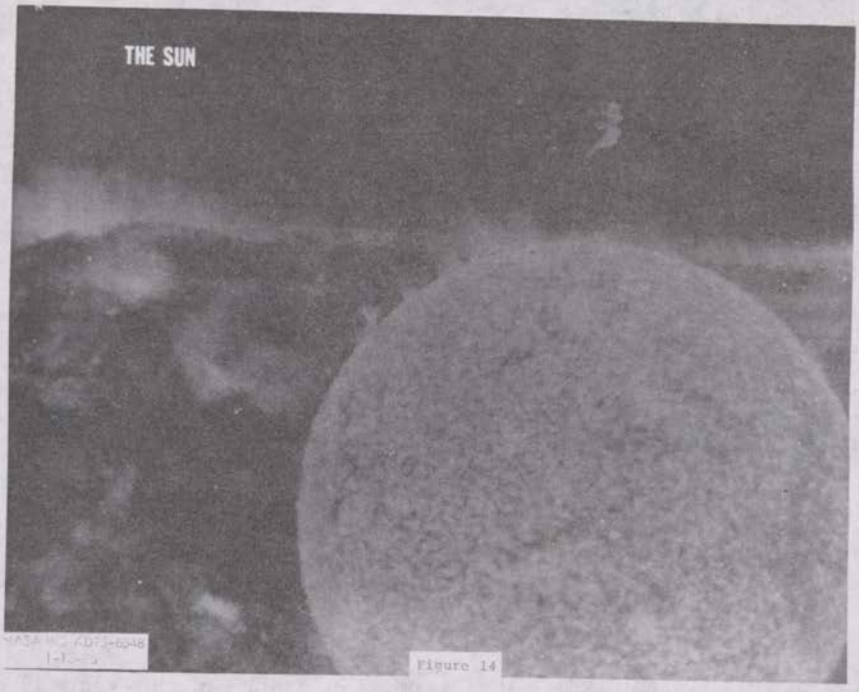


Figure 14

We are trying to determine in detail how what happens on the surface of the Sun affects the weather here on Earth. We are going to launch this year a satellite called the Orbiting Solar Observatory. It will be launched this summer and will take a close look at the Sun. While it is looking at the Sun, it will also look at the Earth's ozone layer. The same instruments which study the Sun will also be able to measure definitively what is happening to our own stratosphere.

SKYLAB SOLAR OBSERVATIONS

Mr. Boland. How high was the Skylab when it took this picture of the Sun?

Dr. Low. 270 miles. Skylab had some extremely good solar telescopes. This particular picture was taken in the ultraviolet light region, which we cannot see from Earth because of the interference of our own atmosphere. It is a picture we could not take from the surface of the Earth. You can see the huge prominences shooting out from the Sun.

SIGNIFICANCE OF LARGE SPACE TELESCOPE

Mr. Boland. How high is the Space Shuttle going to fly? What is its orbital altitude?

Dr. Low. It will be on the order of 100 nautical miles, but it can go higher depending on where we want to inject the payload.

Mr. Boland. Then why do you need a large space telescope if you will have this Orbiting Solar Observatory telescope to take this kind of picture?

Dr. Low. The Large Space Telescope would be able to see much farther into the universe than any existing telescopes. It would be able to see 10 times farther than any ground-based telescope.

I talked about quasars before. These enormous energy sources are out at distances billions of light years away. The space telescope, which would be launched on a Shuttle mission, would improve our ability to see and look at those quasars by a factor of 10 or more. Astronomers tell me that the only way that we will be able to understand quasars and pulsars and other high energy phenomema is to go beyond the ability of today's telescopes.

I should mention that we are not asking for a new program start for the Large Space Telescope this year. We are continuing the study effort. We are requesting $5 million in fiscal year 1976 and $3 million in the transition period for continued advanced technological development and preliminary design. As requested by the committees last year, we are examining lower cost alternatives and exploring possibilities for international participation.

LST CAPABILITIES

Mr. Talcott. At 200 miles out, what are the impediments to seeing into infinity?

Dr. Low. The amount of light that comes toward the Earth and the size of the lens on the telescope.

Mr. Talcott. Are we approaching the limits of what we can build or is the LST we are thinking of building just a further step?

Dr. Fletcher. We don't really know how large the universe is. If current estimates of the size of the universe are correct, the Large Space Telescope would be able to see to the edge of the universe.

On the other hand, there is some debate about how large the universe is. The Large Space Telescope would allow us to see 10 times farther than we can now or see 1,000 times the volume of our own universe. That would be essentially to infinity if current theories are correct.

LST COST ESTIMATES

Mr. Boland. I think you gave us the estimated cost of the Large Space Telescope last year. What was that?

Dr. Fletcher. The projected cost in terms of a "ballpark estimate" was on the order of $400 million. As we mentioned last year, we will not have a planning estimate until the ongoing study efforts are completed. Dr. Hinners may want to add something.

Dr. HINNERS. That is part of our current study efforts. The studies are designed to define various alternatives and cost estimates.

LST STUDIES CONTINUING

Mr. BOLAND. That is a subject that gave the committee some problems last year. We seem to have telescopes and more telescopes. We asked NASA to take a closer look at this. As Dr. Low indicated, there is nothing in this budget to start to procure it, but there are funds requested to continue the study efforts, $5 million in fiscal year 1976 and $3 million in the transition period. These studies will determine whether or not it will be possible to procure the LST cheaper than the cost that was projected.

Mr. YOUNG. May I ask you about that picture? There appears to be a horizon behind the Sun. Is that just some kind of a photographic phenomenon?

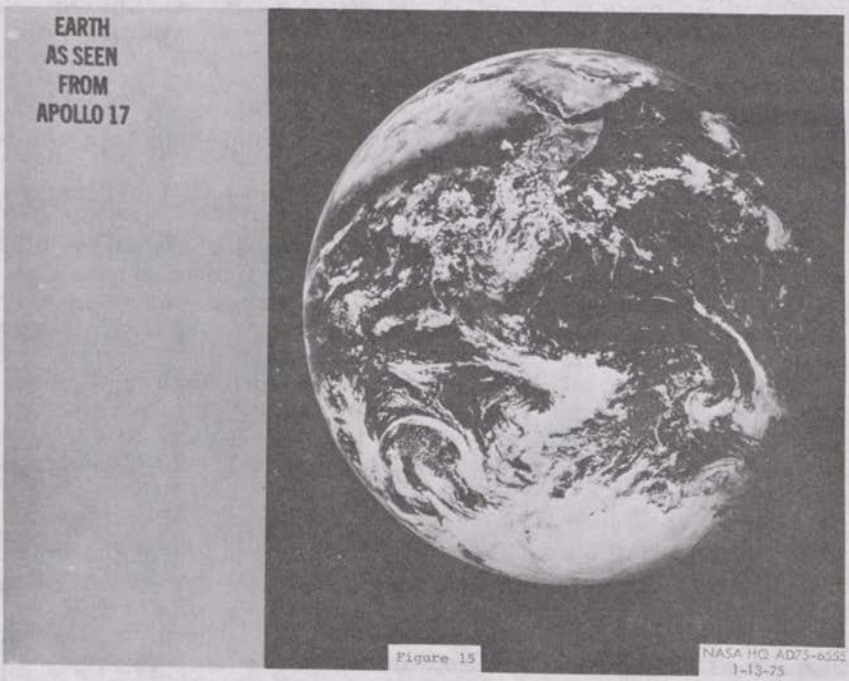
Dr. LOW. It is a huge cloud of gas at a temperature of 50,000 degrees. Different filters are used in front of the telescope and they are able to take slices of pictures at different temperatures. This picture was taken with a filter that allows 50,000 degree temperatures to come through. It would not be visible from the Earth.

Mr. YOUNG. Is that created by the Sun?

Dr. LOW. Yes, sir.

STUDIES OF SUN AND EARTH

I mentioned a moment ago that while we are looking at the Sun, we will be able to look at the Earth with some of these same instruments.



This is a picture of the Earth, taken during the Apollo 17 mission. We have many, many ways of looking back at the Earth now from various unmanned satellites, which brings me to the subject of applications.

APPLICATIONS PROGRAM HIGHLIGHTS

The Applications program includes the weather satellites, Earth resources satellites, Earth and ocean dynamics satellites, pollution monitoring satellites, and communications satellites.

You will notice that in the NASA column here we only have five launches (fig. 16).

APPLICATIONS

	1974	1975	1976	1977	1978	1979
NIMBUS – EXPERIMENTAL METEOROLOGICAL, OCEANOGRAPHIC & POLLUTION MONITORING SATELLITES		▲			▲	
TIROS N – OPERATIONAL PROTOTYPE METEOROLOGICAL SATELLITE					▲	
SMS – SYNCHRONOUS METEOROLOGICAL SATELLITES	▲	▲				
GEOS – OCEAN DYNAMICS MEAS. SATELLITE		▲				
LAGEOS – TERRESTRIAL REFERENCE SATELLITE			▲			
LANDSAT – EARTH RESOURCES SATELLITE		▲		▲		
SEASAT – OCEAN DYNAMICS SATELLITE					▲	
ATS – COMMUNICATIONS TECHNOLOGY SATELLITE	▲					
CAS – US/CANADIAN TECHNOLOGY SATELLITE		▲				
APPLICATIONS EXPLORERS						
– HEAT CAPACITY MAPPING MISSION				▲		
– STRATOSPHERIC AEROSOLS AND GAS EXPERIMENT MISSION						▲

Figure 16

Again this just touches the surface. Most of the applications, once NASA completes the basic research and development, spin off into the commercial sector and Government users such as the weather service.

As I said, out of our 28 launches this year, 18 are in the area of applications, but only 5 are NASA's. The rest are reimbursed to NASA.

I would like to talk briefly about three of NASA's applications missions.

SYNCHRONOUS METEOROLOGICAL SATELLITE (SMS)

The first is a new kind of weather satellite called the Synchronous Meteorological Satellite (SMS) (fig. 17).

Figure 17

This satellite is in an orbit synchronized to the rotation of the Earth. After we go into a very high orbit of 22,000 miles, it will take the satellite exactly 24 hours to get around the Earth if we place it over the equator. It appears to be sitting still over one spot of the Earth.

VALUE OF WEATHER SATELLITE DATA

In this case, the satellite was placed over the middle of the Atlantic Ocean. Most weather satellites until now have been in a relatively low Earth orbit, flying from pole to pole, and covering a strip of the Earth. That type of orbit is very good for obtaining detailed pictures of the clouds. If we want to watch developing weather patterns over a hemisphere of the Earth, by sitting in this high orbit, looking down at the Earth, and snapping a picture every half hour, we can put together a filmstrip of the weather in motion. You are looking at a picture of Hurricane Carmen hitting the gulf coast of the United States. With the synchronous meteorological satellite, we were able to watch the hurricane develop off the coast of Africa, come across the Atlantic, and swing in over the gulf. We were able to predict very accurately

where it would hit, and what its damage potential was. Therefore, the satellite data allowed the weather service to give adequate hurricane warnings.

This was an experimental satellite developed by NASA. The weather service immediately began using it. The weather service will buy more of these satellites through NASA and will use them as a new operational weather satellite system.

SATELLITE LIFE EXPECTANCY

Mr. TRAXLER. What is the life expectancy of that satellite?

Mr. MATHEWS. Its design life is 1 year, but we would expect it to last longer. At least the second or third satellite of this type should have a longer life.

Dr. LOW. The first in a satellite series is experimental. We aim for a 1-year lifetime and that defines the test program. Most of these satellites do not wear out quickly. For example, the first Earth resources satellite, Landsat–1, has now been in orbit for 2½ years. It is slowly wearing out now, but it has certainly exceeded its lifetime.

Mr. TRAXLER. What wears out, the power source?

Dr. LOW. Different things. On the Landsat there is a momentum wheel that is used for stabilizing it. The bearing on that wheel is beginning to wear and malfunction. It is a mechanical failure. In some cases, electronic failures occur.

SHUTTLE /UPPER STAGE CAPABILITY

Mr. TRAXLER. Your Shuttle has about a 100 mile capability. You said with additional effort it could go higher than that. Do you see it reaching 20,000 miles?

Dr. LOW. No, sir, the Shuttle alone will not go up to that altitude but its cargo bay can carry an upper state that can carry a payload to a higher orbit. That upper stage will be used to send the satellite to higher orbits and, ultimately with the full capability upper stage, bring satellites back from the higher orbits. An upper stage is somewhat similar to the last stage on a conventional launch vehicle.

SYNCHRONOUS METEOROLOGICAL SATELLITE

Mr. YOUNG. Do the Russians know where that synchronous meteorological satellite is?

Dr. LOW. Probably; it was announced.

Mr. YOUNG. Does it have any military application?

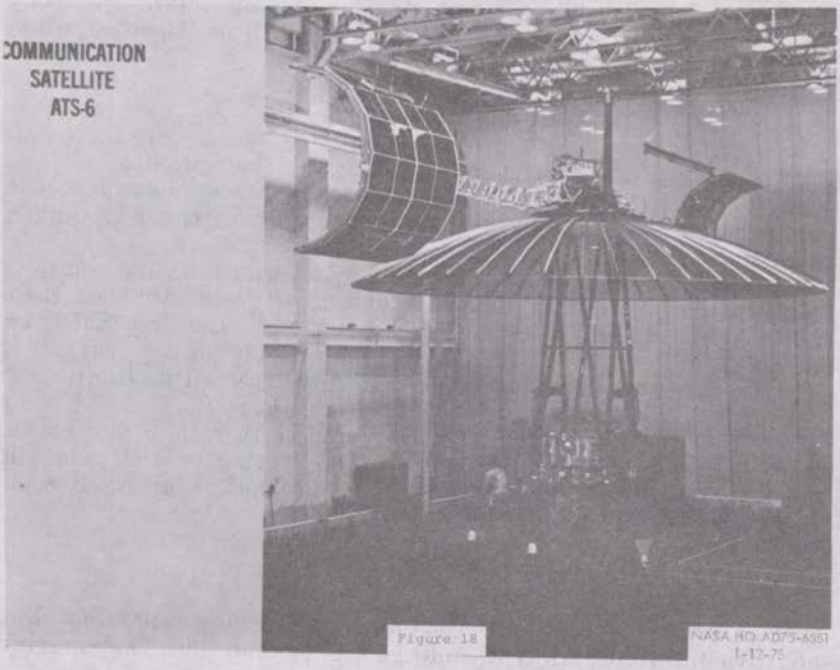
Dr. LOW. No, sir, not directly. If the military services want to use the weather forecasts, they can.

Mr. YOUNG. This is not used for high altitude spying missions or anything like that?

Dr. LOW. No, sir. It takes weather pictures of the kind of definition you see here.

COMMUNICATIONS SATELLITES

I will move on to communications satellites (fig. 18).



This shows the kind of communications satellites which are commercially available now and which are used daily for television broadcasts or trans-Atlantic telephone calls and other communications.

APPLICATIONS TECHNOLOGY SATELLITE–6 (ATS–6)

NASA developed a new kind of experimental communications satellite which differs from the existing commercial ones in that it has an extremely large antenna. This communications satellite, which is called Applications Technology Satellite–6, has a 30-foot antenna and a very high-powered transmitter. Because of the large antenna and high-power capability in space, it can communicate with very small, inexpensive transmitters and antennas here on Earth.

NASA'S WEATHER SATELLITE PROGRAM

Mr. BOLAND. Turning back to your weather satellites, how many have you had and what were the results? Would you supply that for the record?

Dr. Low. We will be glad to.

[The information follows:]

NASA has successfully launched 31 weather satellites since the first one, Tiros–I, was launched on April 1, 1960. The usefulness of the data derived from these meteorological satellites has proved to be so great to our national weather services that, as early as the mid-1960's, the U.S. Weather Bureau—now the National Oceanic and Atmospheric Administration—established a National Operational Meteorological Satellite System whose purpose is to make the beneficial products of satellite meteorology available for routine daily use.

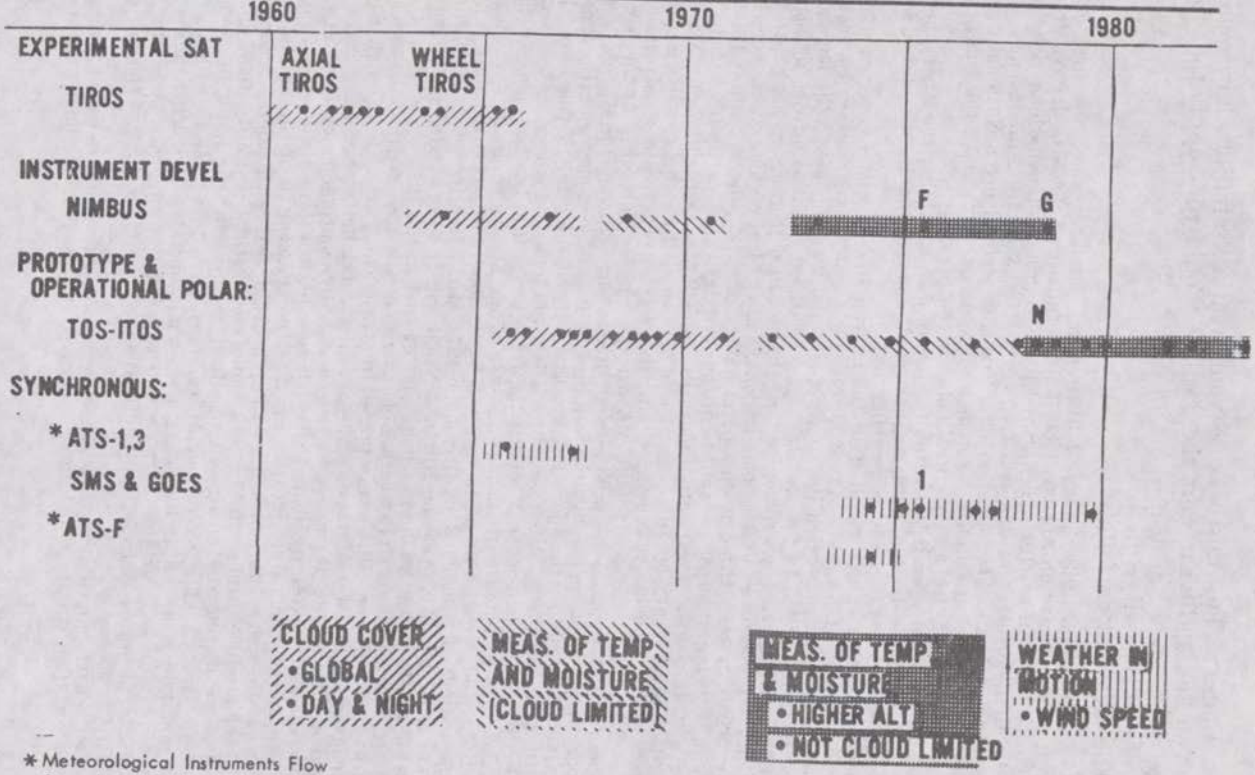
The R. & D. and operational satellites involved in obtaining the atmospheric data used for the detection, analysis, and prediction of significant weather features are categorized in the accompanying chart.

The early Tiros efforts resulted in the surveillance of cloud cover over the entire world on a daily basis so that movements of major weather systems could be determined and improvements in forecasts and warning achieved. This was particularly important in the monitoring of weather systems approaching populated areas from areas where conventional means of detection are not practical, such as the broad ocean areas, polar regions, and tropical regions. Later versions of the Tiros system, through incorporation of infrared sensing, allowed cloud cover monitoring at night as well as during the day. Such capabilities were incorporated into operational satellites in the mid-1960's. Meanwhile, the Nimbus experimental program began to develop a new capability, the measurement of temperatures by means of remote sensing. These temperatures are measured on the surface and at various altitudes above the surface any place in the world. Temperature is a primary measurement utilized by weather forecasters. Such temperature measurements, having been proved out in the experimental program, were incorporated into the operational program in the early 1970's. One limitation existed in this capability—temperatures below the tops of clouds were impossible to obtain under cloud-covered conditions. Once again, the Nimbus experimental program demonstrated that through the use of microwave equipment which can penetrate cloud cover this problem could be circumvented. This capability, first demonstrated on Nimbus E in December 1972, will be verified by an improved system to be flown this year on Nimbus F, and will be incorporated in the operational Tiros–N series to be flown in the latter part of the 1970's.

Lastly, another approach to weather observations was demonstrated in the latter part of the 1960's. Satellites were placed in synchronous orbit, an orbit that has the characteristic of maintaining the satellite continually over the same geographical area. This feature provides essentially continuous observations of almost the entire Western Hemisphere. These satellites were equipped with television cameras which were ideally suited to the observation of the buildup and movements of severe storms such as a hurricane, or severe thunderstorms of the kind that produce tornadoes. The continuous observation capability also enables the measurement of wind speed as determined by the motions of individual clouds or cloud systems. The experimental versions were immediately utilized for operational purposes, but in the past year two new operational synchronous satellites were launched for this purpose and are now continuously observing the entire United States, Canada, and South America, as well as most of the Atlantic and Pacific Oceans.

Satellite system have proved invaluable to this country and are used by nations throughout the world in obtaining improved weather predictions and storm warning.

EVOLUTION OF METEOROLOGICAL SATELLITES



* Meteorological Instruments Flow Piggy back on these Experimental Communications Satellites

NASA HQ ER74-15085 (1) 7/31/73

ATS–6 OBJECTIVES

Mr. BOLAND. Does ATS–6 look that way in space? Would you summarize its objectives and achievements to date?

Dr. LOW. Yes, sir, this is the way it looks in orbit. This Applications Technology Satellite was launched last summer. It is in a geosynchronous orbit. Because it has this very high power in space, it can communicate with locations on the ground, such as hospitals and schools in remote areas. It has been successfully used in experiments which we jointly performed with the Department of Health, Education, and Welfare in education in Appalachia and in remote health care in Alaska.

The satellite has helped save the lives of Alaskan Eskimos in remote villages because a paramedical person—a nurse or a medical technician in a village—can communicate, via the satellite, in two directions. A doctor in a hospital in, say, Fairbanks, Alaska, can be consulted. The patient's illness can be diagnosed and the right treatment can be prescribed by the doctor via satellite.

It is a new way of communicating two ways, to and from remote locations, without requiring the very large ground antennas or ground systems that don't exist in remote locations such as parts of Alaska.

USE OF ATS IN EMERGENCIES

Mr. BAUCUS. How does one communicate? Supose I am in a village or stranded on a mountain top with a broken leg.

Dr. LOW. The Applications Technology Satellite is an experimental system which is being used in predetermined locations where the villages are equipped with receivers. In an emergency, a call can be placed right away. Normally we work at scheduled times because these experiments are only two or three of many other technology experiments being conducted with the satellite.

ATS SEARCH AND RESCUE EXPERIMENTS

Mr. BOLAND. Mr. Baucus would like to know whether or not he would be able to communicate, using a little instrument of his own, if he were on the top of a mountain and broke his leg. Could he call for help?

Dr. FLETCHER. That is a good question. We are going to try an experiment on search and rescue using this satellite. That particular experiment has not been done yet. It will be done this month.

MONITORING USE OF ATS–6

Mr. TALCOTT. Who does monitor it to keep guys with relatively minor problems from using up all the circuits when you need them for a flood or something?

Mr. MATHEWS. The experiment we are talking about is designed to determine the ability of the satellite system to detect emergency situations of the type that occur at sea, for example. This type of experiment will ultimately provide a basis for global air-sea search-and-rescue capability. It would include a land-rescue capability. It is very

easy to provide the necessary bandwidth and the means of communicating to any place in view of the satellite itself. This satellite, which is in a synchronous orbit, can detect the distress signal and relay it to a ground station to call attention to the emergency. It would not be a television signal. The signal would be an emergency code, indicating that an emergency had occurred, and the location of the emergency.

ATS GROUND RECEIVERS

Mr. TALCOTT. Would each ship have to be equipped with a very sophisticated communication system?

Dr. FLETCHER. No; it would be a relatively small, simple communicating device of a few watts.

Dr. LOW. Mr. Talcott, we saw a demonstration carried out with one of these satellites where a very small antenna had been put together out of coathangers and an umbrella, and a walkie-talkie was used as a transmitter. We were able to communicate from the steps of our building in Washington to Venezuela and Iceland on one of these experiments. The ground station does not have to be complicated.

VERSATILITY OF ATS COMMUNICATIONS SYSTEM

Mr. BAUCUS. How many circuits does it have? What if several people have problems at the same time?

Mr. MATTHEWS. That's really expressed in terms of bandwidth. The main video bandwith runs from 2.5 to 2.69 gegahertz. A gegahertz is a frequency of a billion cycles per second. A tremendous amount of information can be relayed through a band of that width.

Dr. LOW. That band could carry half a dozen color television pictures at the same time, which alternately translates into hundreds of telephone lines for each television picture. The applications technology satellite–6 is designed to handle two-way television or two television pictures simultaneously. You can use the available circuits for something very complicated like a television picture. You can use it any way you want to in any combination. The system is versatile.

Mr. BAUCUS. Thank you.

LANDSAT EARTH RESOURCES SURVEYS

Dr. Low. Moving on to Landsat, our Earth resources satellite (fig. 19).

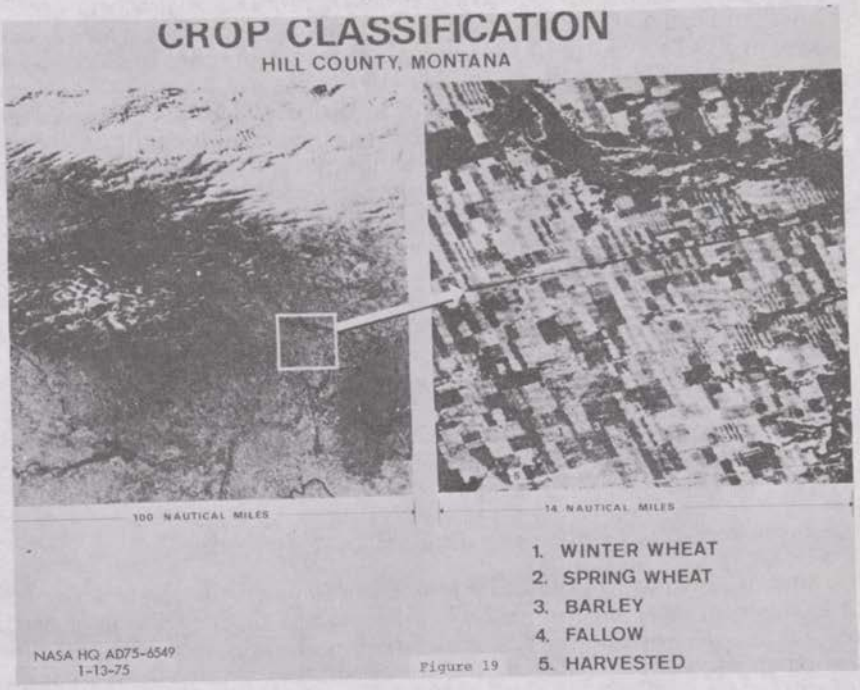


Figure 19

We just launched the second Earth resources technology satellite, Landsat–2, on January 22, 1975. I wanted to explain how we can use this satellite to measure crop acreage and to predict the yield of various crops. Mr. Baucus, I have used this slide for a long time now. I learned just yesterday that you district starts over here.

Mr. BAUCUS. About 2 miles away.

LANDSAT CROP MEASUREMENTS

Dr. Low. Liberty and Hill County are shown in the picture, so it is very close to you.

This is a picture of several counties in Montana, right along the Canadian border. It covers an area 100 miles by 100 miles, which is the way LANDSAT normally takes a picture. It does not really take a photograph. It takes electronic signals which are then put back together down here in a computer, and reconstructed into a picture. But it is able to see features on the Earth not as we see them, in one spectrum of colors; it can cut the color band apart. It can take pictures in just red, just green, or just blue. Generally, we like to see and take the picture in the green and blue and two slices in the so-called infrared, which we cannot see with our own eyes. If we put the picture back together in the computer, we can print out, in different colors, different features on the Earth.

Water appears as a different color from snow, as it does even in visible light. Asphalt appears different from concrete. We can identify crops.

What I have called out here in this little square, which is one-quarter of a mile, is winter wheat. It comes out as a bright red color. Spring wheat, which is farther along, looks a darker red. Barley is an even darker red over here. This square over here on the left is fallow. It has adready been plowed under.

VALUE OF LANDSAT DATA IN CROP PREDICTIONS

One can, by using the satellite and using the information that is put into the computer on the ground, differentiate or classify the crops. We can, with these satellites, measure how large the fields are. We can then use the computer to add up all of the winter wheat in Hill County, Mont., all of the wheat in the State of Montana, or the United States or the world.

In agriculture alone the satellite has a capability of measuring how much there is of a certain crop. By classifying the crop, measuring how much there is, and combining this information with current weather information, one could predict what the yield will be—how many bushels per acre. On a small scale now, but ultimately on a world-wide basis we will be able to collect data on food production in terms of crop inventory and predicted yield.

LARGE AREA CROP INVENTORY EXPERIMENT

We are conducting a joint experiment with the Department of Agriculture and with the Department of Commerce which we call the Large Area Crop Inventory Experiment (LACIE). It is designed to determine how the Landsat can be used in agriculture to predict world food production in various crops. The ultimate goal, of course, is to have more food available for less money. The potential of the satellite to help alleviate problems in this area was, as you may remember, mentioned at the Rome Food Conference.

We have had economic analyses of what this type of data might be worth to the economy. The studies are not yet conclusive, because we have not yet completed all the experiments. However, there have been estimates as high as $500 million to $1 billion annual return to the

U.S. economy from using a satellite like Landsat in agriculture, in water runoff, and in land management.

LANDSAT CROP DISCRIMINATION

Mr. TALCOTT. How discriminating can you be? Spring wheat can vary in maturation in Hill County by several weeks. It could be more than several months all around the globe.

Dr. LOW. That is a very good question. That is one of the things we have to find out from the experiments we are now conducting. We do know that something that looks like spring wheat in one area will look exactly the same in the general region, but we do not know how far we can extend this knowledge. We do not yet know how often we have to take what we call "ground truths" data to measure the actual conditions, or how often we have to calibrate the instrument. That is one of the areas where we have to learn more.

Dr. FLETCHER. If you can take a reading on that farm every 18 days, you can watch the progress of the crop. Even though it may differ in another part of the country from Hill Country because of different growing cycles and harvest times, you can collect better information from periodic readings than from just one reading.

Mr. TALCOTT. Spring wheat will have 6 inches of rain in one part of the area and 3 inches in another. That will make some difference. Some will have a blight or disease. In some cases, the ground will be different. It seems to me that the discrimination is going to be a real problem.

Dr. FLETCHER. Yes, but that is why you use a satellite. With Landsat, you can watch the growth of the crop from its beginnings. First it is fallow, then you begin to see a little bit of the greenery; then all of a sudden you will notice that there is a dropoff. Obviously something happened, a disease or a storm. By combining that data with weather data, you ought to be able to have a pretty good estimate, versus time, as to how the crop is doing.

CORN BLIGHT STUDIES BY NASA

Dr. LOW. Three years ago the so-called corn blight occurred throughout the Corn Belt in the Midwest. We ran experiments, using these same instruments in airplanes, and found we could very precisely predict the extent of the corn blight in different regions.

LANDSAT MANAGEMENT AND USERS

Mr. BAUCUS. Who are the users and who manages this satellite?

Dr. LOW. Landsat is one of NASA's experimental satellites. It is our job, with annual authorization and appropriations from the Congress, to bring the space technology into being. NASA manages the total project, but there are investigators who belong to universities and to various agencies and departments in the country and around the world. The scientists, the people who study how to use the data, come from all over the world.

Now that is phase 1. Phase 2 is the demonstration and verification phase which we are in now with the Large Area Crop Inventory Experiment, LACIE. This is a joint project involving NASA, Agriculture and NOAA. We have joint achievements and we are jointly managing that project.

The question of which agency would be the ultimate manager will not be determined until the verification efforts are completed, perhaps 5 to 6 years downstream.

LANDSAT-C APPROVAL

Mr. BOLAND. With respect to Landsat-C I noted that you had the launch in 1977 marked with a circle. Why is that?

Dr. LOW. I should have pointed this out. There was some discussion as to whether we should proceed with the development of the third Landsat or not. The decision was made in the budget process that we should proceed. I wanted to use this circle to remind me to mention that we are starting development of a third Landsat, Landsat-C as authorized by the Congress in the fiscal year 1975 budget.

ORIGIN OF LANSAT-1

Mr. TALCOTT. Why is Landsat so far ahead of Seasat, when I thought that Seasat was begun first. This is the first year we have heard about Landsat.

Dr. LOW. Landsat was started considerably before Seasat. It used to be called the Earth Resources Technology Satellite—ERTS. The first one was authorized in fiscal year 1970. Development of a third one is providing for continuity of data needed to explore the full range of potential benefits from these remote sensing systems.

Seasat is a brand-new satellite, which was authorized by the Congress last year. It takes this many years to develop the first of a kind.

ERTS NAME CHANGE TO LANDSAT

Mr. TALCOTT. Why do you change the names as you go along like this? Is that to confuse people?

Is it a budgetary gimmick or what?

Dr. LOW. We hope Landsat is more descriptive than ERTS was. Many of us disliked the acronym ERTS and we were looking for something descriptive to go along with Seasat, Stormsat, and others. Changing a name in the middle of a project was difficult but we thought it would be best to have a descriptive name instead of an abbreviation.

LANDSAT-C APPROVAL

Mr. BOLAND. With respect to Mr. Talcott's question, I have a question regarding the earth resources program. I think you have given the answer anyway. I notice that NASA has once again decided to change names in midstream. Landsat was for many years called ERTS. NASA has a penchant for name changing, which is a bit baffling. In any case, we note with satisfaction that Landsat has finally received a go-ahead. I understand that the President gave it the final approval. It is a very useful satellite that this committee was intensely interested in. OMB was not particularly enamoured by it. However, as a result of the efforts of NASA and this committee, we finally have it approved, leading to launch in 1977.

This is the third ERTS or Landsat; is it not?

Dr. LOW. Yes.

Mr. TALCOTT. When you first started out with these satellites, we were studying the whole Earth. Now we are getting more specific,

it's land and sea. I think we ought to make all these things clear as we go along instead of a quiet little shift that nobody recognizes and doesn't really know the purpose for.

Dr. Low. I apologize for not mentioning both of these.

AERONAUTICS PROGRAM HIGHLIGHTS

Let me move on to NASA's aeronautics efforts. Our aeronautics program, consistent with our charter, is far reaching. It is broad in that it ranges from airplane energy conservation and environmental effects to improved performance of airplanes. We are also emphasizing general aviation and aviation safety. I would like to talk about only one focus of our aeronautics program. That has to do with the aeronautical energy conservation (figs. 20 and 21).

AERONAUTICS

- ENERGY CONSERVATION
- ENVIRONMENTAL EFFECTS
  - NOISE
  - POLLUTION
  - AIRPORT CONGESTION
- PERFORMANCE
  - VERTICAL AND SHORT TAKE-OFF AND LANDING
  - LOW-SPEED
  - TECHNOLOGY FOR HIGH SPEED FLIGHT
- GENERAL AVIATION
- SAFETY

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Figure 20

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AERONAUTICS

- MAJOR EMPHASIS ON REDUCED ENERGY CONSUMPTION
  - REDUCE DRAG
  - REDUCE WEIGHT
  - MORE EFFICIENT ENGINES
  - MORE EFFECTIVE CONTROL SYSTEMS
  - BETTER OPERATING PROCEDURES
- 50% POTENTIAL FUEL SAVINGS
  - SAVE ⅓ MILLION BARRELS CRUDE OIL PER DAY
  - SAVE $1.3 BILLION PER YEAR
    (ASSUMES CURRENT FLEET SIZE)

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Figure 21

FUEL-CONSERVATIVE AIRCRAFT TECHNOLOGIES

Our technologies are beginning to come together to give us a 50-percent potential fuel savings in the commercial fleet of aircraft (fig. 22).

We do this by new shapes of the wing, which reduce the resistance

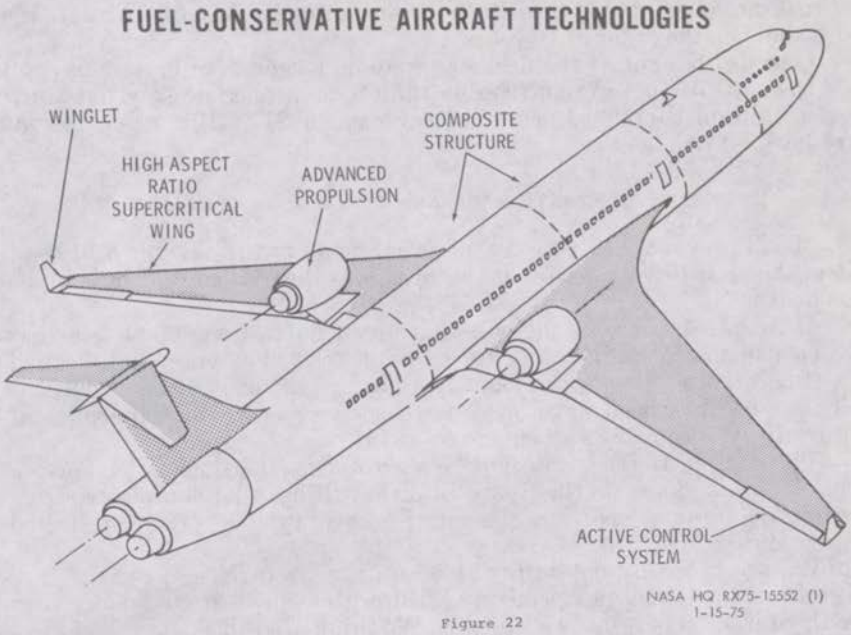

Figure 22

of the airplane as it flies through the air. We also do this by using different kinds of materials in the structure called composites. They are carbon fibers bonded together with certain bonding materials which are much stronger and lighter than metal. Therefore the composites make the airplane lighter and reduce weight, which in turn reduces fuel consumption. We do this by designing more efficient engines in our laboratories and by designing better control systems and working on better operating procedures to avoid the tremendous losses of energy that occur, for example, when an airplane circles around a field before it can land. When we put all these technologies together, we can predict fuel savings of 50 percent or more.

Now this is technology which has been developed in our computers, in our wind tunnels, and in our experimental labs. It takes time before

this kind of technology can find its way into the fleet of aircraft. We estimate on the order of 10 years.

Once it does and if the fleet size were no larger than it is today, and if the costs of fuel were no higher than today, we could save one-third of a million barrels of crude oil per day, or $1.3 billion per year at today's oil prices.

DEMONSTRATION OF AIRCRAFT FUEL SAVINGS

Mr. BAUCUS. When you say potential, you say the savings will be at least that in 10 years. How much of this is theoretical and how much is proven?

Dr. LOW. A rough number is that about half of the 50 percent has been demonstrated in tests. For example, the new wing shape called a supercritical wing, significantly reduces the drag of the airplane. This wing has been developed and has been flown on experimental aircraft. We know what it can do.

The composite structure will be used in the Space Shuttle. The big payload bay doors on the Space Shuttle will use that composite structure. We know we can use the active control systems. We have tested airplanes using them.

We are probably not as far along on the aircraft engines as we are on almost everything else. I say with a great deal of confidence that half of that 50 percent is realizable. We think all of it is.

ADVANTAGES OF SUPERCRITICAL WING

Mr. YOUNG. On the new wing, how is the lift capability affected?

Dr. LOW. The new wing will give the same lift with less friction or less drag in the air at the same speed.

Mr. YOUNG. In conjunction with the question that Mr. Baucus asked, you have already proved this?

Dr. LOW. We have flown that wing on an F–8 airplane which is a former Navy fighter which was reequipped with this kind of a wing. We have demonstrated in flight that the wing will indeed do what we have shown by testing.

Mr. YOUNG. What about its strength and maintenance?

Dr. LOW. As far as the wing is concerned, it is probably stronger and lighter because it can be made a thicker wing. Because of the shape it can be made thicker so that the structure inside the wing is simpler to make and the wing will be stronger.

FUEL-CONSERVATIVE AIRCRAFT TECHNOLOGY SAVINGS

Mr. BOLAND. Over what period of time is all of this possible?

Dr. LOW. The technology for this 50-percent savings should be fully in hand within 10 years. Much of it could be applied earlier and we see it going into the next generation of aircraft as soon as the aircraft come along.

Mr. BOLAND. This could present a problem to the aircraft industry. The costs, I would think, would be considerable in altering the planes flying at that time.

Dr. LOW. I don't think that the large existing airplanes would be altered to incorporate these improvements. There may be a few small

exceptions, but we are looking at what the next generation of airplanes will be.

Many planes flying today will be very old 10 years from now and the airplane industry will have to come in with a new generation. We are working very closely with the industry in terms of an advisory structure on just the problem of what it is that we should do and how do we bring it into the industry. We do not want to work on solutions that the industry will not use.

PATENT POLICY

Mr. BAUCUS. When NASA develops and proves technology on, say, efficiency of engines, how does private industry get the rights to develop it, who owns it, when do you work jointly, and how does that all work out?

Dr. LOW. That is a very complex question to answer.

Mr. BAUCUS. I realize it is complex.

Dr. LOW. In terms of general technology, such as the invention of a new wing shape which is done during years of theoretical work by universities and at our centers in our wind tunnels, we have patents. We can decide whether or not to charge for the patents as the industry uses them.

In terms of specific developments, we are working with one aircraft engine manufacturer to develop a quieter engine. We have in that contract what we call a recoupment clause. It is a clause which allows the Government to get paid back from sales, as the contractor starts selling that engine, to recoup the cost of research and development.

So we are going from basic theoretical work which is part of NASA's charter and responsibility to do for the country as a whole, where we do not get any restoration of recoupment, to the very specific developments where we can get full payback by the contractor.

Mr. TRAXLER. Are you telling us the contractor is permitted to hold the patents, and on the successful practical applications you get paid back?

Dr. LOW. In some cases, we have a choice of getting paid back, yes, sir.

Mr. TRAXLER. If it is an unsuccessful practical application you pay the costs and the contractor has technicians developing the skills and perhaps out of that can come subsequent commercial applications which he can patent and derive a profit out of it. It seems that is the finest illustration of the free enterprise system at work. That is just a comment.

Mr. TALCOTT. What was the comment?

Mr. TRAXLER. I said it is a fine example of free enterprise at work through Government subsidies.

Mr. TALCOTT. I don't think that was a fair comment.

Mr. TRAXLER. I didn't expect you to agree with me.

NASA'S ROLE AND RESPONSIBILITIES IN AERONAUTICS

Mr. BOLAND. Before NASA was created, we had the National Advisory Committee for Aeronautics. It was called NACA. NASA came

into existence in October 1958 after Sputnik was launched by the Russians.

NACA's responsibility at that time and its mission was in aeronautics. A great many of the advances in aircraft—the configuration of the aircraft, the wings, about every major advance you can think of—was in a sense developed by NACA, was it not? Is that a fair statement?

Dr. Low. Yes, sir.

NASA'S AERONAUTICS RESEARCH AIDS TRADE BALANCE

Mr. Boland. So the Government has been in aeronautical research and technology for a long, productive period of time. That is the reason why we have some of the finest airplanes in the world and why our airplanes are competitive in the world marketplace. Aeronautics is an important part of our trade balance.

Dr. Low. The responsibility is in NASA's charter, as you said, to advance aviation research and technology in this country. This type of technology effort allows the United States to sell most of the airplanes which are today flying in the free world and to remain at the forefront of aeronautics in the world.

NASA-TYPE TECHNOLOGY APPLIED TO TRANSPORTATION NEEDS

Mr. Talcott. I hope nothing is excerpted from this testimony to discredit NASA or discredit its relationship with private industry. We should be proud of the seven-to-one return we are getting from NASA and all the great things this committee has been working on with NASA for a long time.

May I ask how we could convert some of this aircraft technology to buses and trucks that go along the highway? We see all these square boxes which must burn large amounts of fuel because of the drag. How do you convert from space technology to buses and trucks?

Dr. Low. We do have a joint project with the Department of Transportation to apply these technologies to vans and trucks. The results are quite encouraging. So it does spin off into those fields.

REDUCING AERODYNAMIC DRAG OF TRUCKS AND VANS

Mr. Boland. Then you are actually engaged in research in this area now with DOT, are you not?

Dr. Low. Yes, sir.

Mr. Boland. That would reduce the use of fuel and perhaps make the trucks and vans more effective.

Dr. Low. The intention is to reduce the resistance encountered as the trucks and vans going through the air and thereby to reduce the fuel consumption. We can do this rather well.

WINGLET POTENTIAL

Mr. Young. Before you leave that slide, let me ask another question. I am interested in the winglet. Is that part of the supercritical wing or part of the control system?

Dr. Low. That is part of the higher efficiency airplane. It is related to the supercritical wing. The same man who invented the supercritical wing, Dr. Whitcomb, has recently come up with the winglet which also increases the efficiency of the wing. According to his calculations, it could lend to about a 5 percent fuel reduction. It might be possible to apply this concept to an airplane without rebuilding the whole wing. It might be retrofitted onto existing airplanes. The aircraft industry is now looking at that possibility. It does make the wing more efficient and does cut down on fuel consumption. It may be one of the items that could be retrofitted onto existing equipment.

Dr. YOUNG. What does the winglet do?

Dr. Low. One way of making the wing more efficient would be to make it a longer, straighter wing. In our jargon, that is called increasing the aspect ratio. However, when you do that, you generally add quite a bit of weight. The winglet changes the flow over the tip of the wing where the flow goes from high pressure at the bottom to low pressure at the top in almost the way that a longer wing would. Therefore, it gives you the effective benefits of this larger wing without increasing the size very much.

Mr. YOUNG. So it goes to the lift?

Dr. Low. It goes into the lift of the wing.

Mr. YOUNG. Are there any movable control surfaces?

Dr. Low. No; there are not.

IMPROVED AIRPORT OPERATING PROCEDURES

Mrs. BURKE. Do you anticipate that there will have to be any modification in existing airports and landing strips with a faster takeoff and landing pattern that you would establish with a more efficient kind of aircraft?

Dr. Low. Mrs. Burke, we are looking for ways to make better use of existing airports rather than to introduce changes in existing airports. One of our efforts focuses on better operating procedures, which is to find ways that the planes can get in and out of airports more efficiently, using existing runways and existing systems.

SHORT TAKEOFF AND LANDING AIRCRAFT

Mrs. BURKE. Would this kind of improved aircraft with reduced weight and less drag assist some of our airports that are now unable to accommodate the larger aircraft or would it mean you would need additional landing areas?

For instance, would National Airport be able to utilize this kind of aircraft where it cannot now?

Dr. Low. National Airport could be utilized for this kind of an aircraft, as it is today used for most of the small aircraft fleet. National Airport today, as I understand it, could also handle the wide bodies. However, for other reasons, the airport itself would become too overcrowded, and that is why the runways are not lengthened.

There is another area called short takeoff and landing (STOL) aircraft which can land on shorter suburban airports. Some of these technologies would also apply to the STOL aircraft. But the intention is to make the longer range aircraft more efficient so that they use less

fuel. As we discuss aeronautics in our budget, we will come to the short takeoff and landing aircraft.

Mr. Chairman, I have one more topic.

NASA'S CONTRIBUTION TO ENERGY AND RELATED EFFORTS

NASA is also doing in other fields, nonaeronautics and nonspace fields (fig. 23).

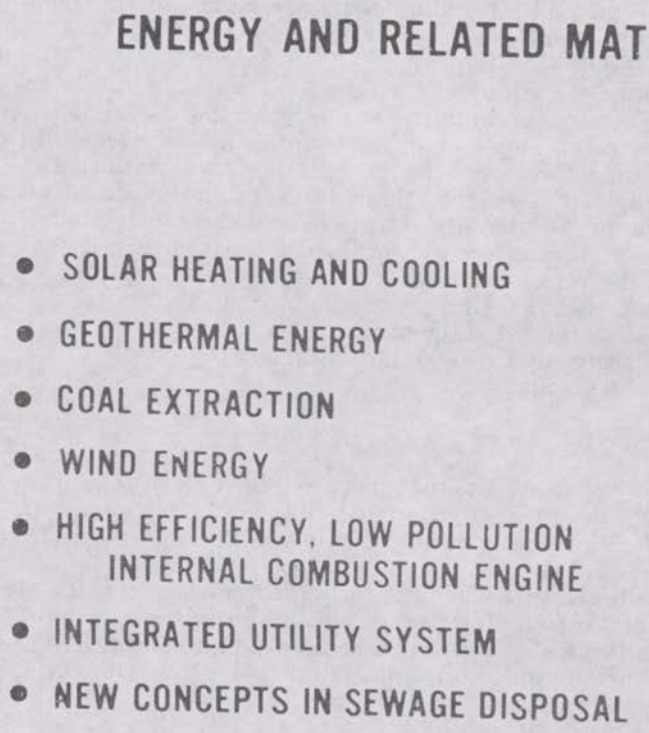

Figure 23

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We have technologies which apply particularly in the field of energy. We are now working with the Energy Research and Development Administration, and we worked with their predecessor agencies, to see how we can apply NASA's expertise, management abilities, and technologies in order to support them in their efforts.

SOLAR HEATING AND COOLING

We are working with the Energy Research and Development Administration on solar heating and cooling. I discussed that at the be-

ginning of my talk. This is a demonstration house at our Marshall Space Flight Center in Huntsville, Ala. (fig. 24).

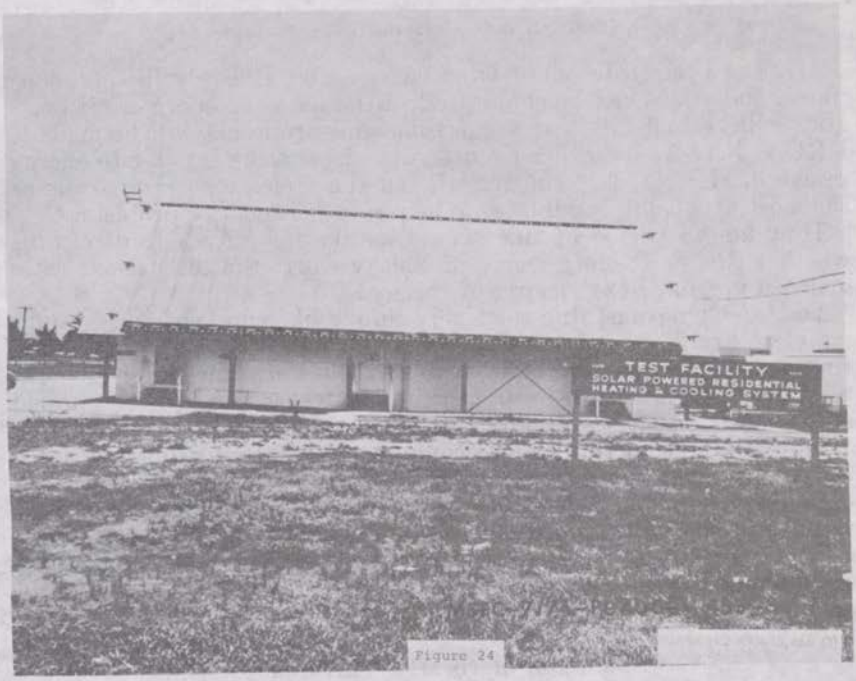

Figure 24

It uses the coating developed for Skylab to get efficient use of the Sun's rays in solar heating and cooling.

GEOTHERMAL ENERGY

We are also working with ERDA on how to get energy out of the ground and the oceans—the so-called geothermal energy sources.

MINE SAFETY AND COAL EXTRACTION

We are also working with the Department of the Interior on coal extraction. You might ask why NASA's in this business. The Department of the Interior came to us for help on two problems. One has to do with the safety of the coal miners, who are exposed to strange environments and have all sorts of safety problems. These problems are the same kinds of safety problems we tackled in the manned space flight programs. Therefore, we can help the Department of the Interior in their efforts to improve the safety of the miners. This technology spins off from our Apollo and Skylab life support equipment techniques.

Second, we have learned a great deal about how to automate equipment. That same automation applies to the coal-mining field. That is why we are working on coal extraction.

We are also working on windmills energy for ERDA to see whether or not one can get enough power out of the wind to make a contribution to alleviating the Nation's energy problems.

ENERGY R. & D. COST-BENEFIT RATIOS

Mr. BOLAND. In terms of wind energy, and I have said this many times, many sins can be committed in the name of energy and probably will be. All kinds of suggestions and proposals will be made to ERDA, NASA, and other agencies that have some input into energy research. How quickly can we sift out the useless ones and focus on the most promising candidates to help solve our energy problems?

How long a period of time would it take for NASA to determine whether this is a viable source of energy where the cost-benefit ratio makes it possible to be a source of energy?

Dr. Low. On something relatively simple like wind energy, I would imagine 2 to 3 years. In 2 to 3 years, one can design and determine the costs of wind generators and at the same time determine the total system analysis of its use, including where would it be applied and whether or not it would be cost-effective.

If you take something more complicated, such as using hydrogen as an economical fuel source instead of the hydrocarbons, we are using today, I imagine it would take much longer. The question of how you generate the hydrogen, how safe it is, and how you use it would take longer to study. I think the real answer as to whether one should pursue hydrogen as a major fuel source in this country would take anywhere from 5 to 10 years.

SEWAGE DISPOSAL TECHNIQUES

Mr. TALCOTT. I have heard from people pretty knowledgeable in new concepts of sewage disposal. They came to you and they were utterly amazed that your people would understand and know about sewage disposal and conversion of sewage to useful products. They could not believe that people interested in deep space would have this kind of knowledge.

I wanted to pass along that compliment.

MODULAR INTEGRATED UTILITY SYSTEM

Mr. BOLAND. Let me ask a question about waste disposal. They have developed a compactor now that is absolutely incredible. You can compact so much in those kitchen compactors. It is so incredible that it is almost impossible to lift the bag out. Now I understand that some States are looking at the problem because there is no way to dispose of it.

It will not burn. It will sink but there is no place to sink it. What do you do with a problem like that?

Are some States looking at the problem of the disposal of that which is made by the compactor?

Dr. Low. Mr. Chairman, at our Johnson Space Center in Texas, we are working on a modular intergated utility system, again making use of the technology used in our spacecraft, to see whether or not we can recycle everything in a home, including waste, and conserve energy that way.

We also looked at the possibility of heating and cooling our Langley Center putting a major trash burning facility close to Langley and using all the trash from the city of Hampton, Va. The idea was to burn the trash and use it for the utilities at Langley. It is not in our budget because we did not have the money within the limitations of this year's budget. But the recycling of waste can be done.

HYDROGEN INJECTION AUTOMOBILE ENGINE

I will very quickly cover this item (fig. 25).

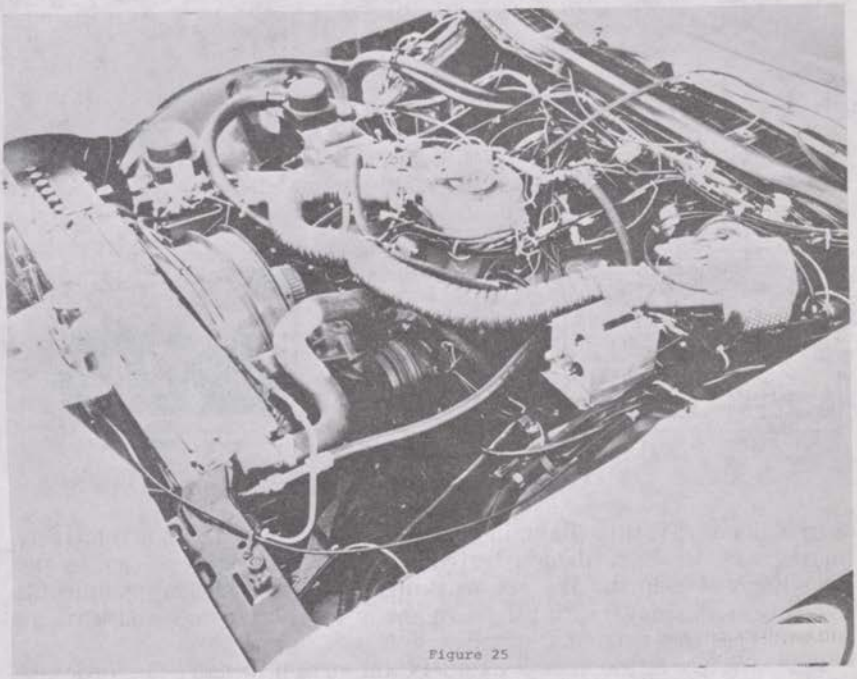

Figure 25

This is an automobile engine into which hydrogen is injected. The work is being done by the Jet Propulsion Lab. By injecting hydrogen into an automobile engine you can accomplish two things: (1) reduce the gas consumption; and (2) significantly reduce the pollution. This project is underway at the Jet Propulsion Lab in California, and is another example of applying NASA technology to a down-to-earth problem. We anticipate that during FY 1976 this hydrogen injection engine project will be conducted in coordination with the Energy Research and Development Administration. A demonstration plan covering the next phase of the project will be prepared for ERDA's consideration. It will outline plans for a demonstration of the engine with an onboard hydrogen generator in an automobile.

WATER PURIFICATION BY ACTIVATED CARBON FROM SEWAGE SLUDGE

Another example concerns a sewage plant. People at the Jet Propulsion Lab who were looking for a better way to make activated carbon for rocket nozzles found that way by using sewage sludge. They used sewage sludge to make the activated carbon which they

needed for rocket nozzles. They then came up with a concept of using the sludge directly in a sewage plant to make the activated carbon and clean up the sewage (fig. 26).

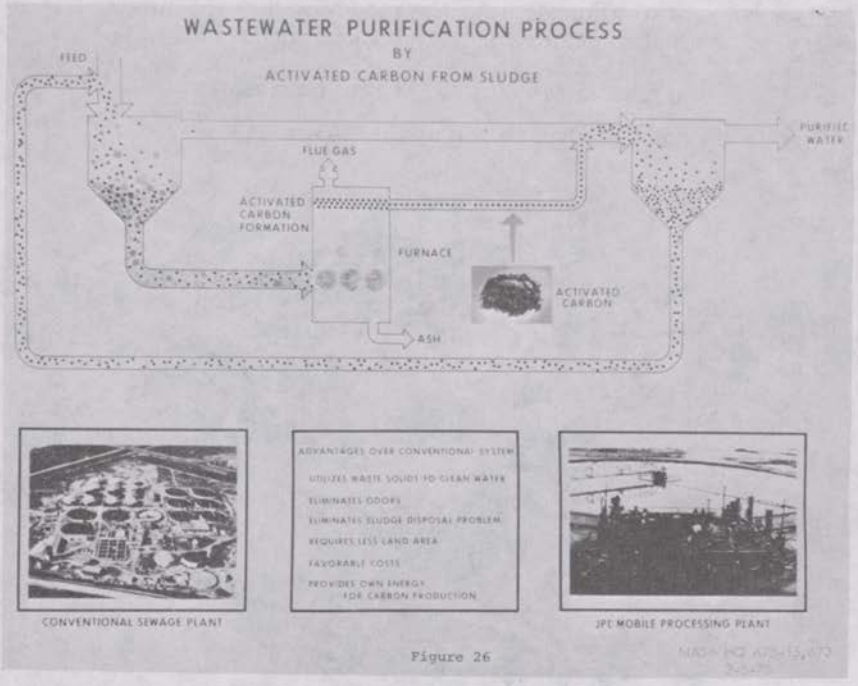

Figure 26

In a demonstration plant in Orange County, Calif., on a relatively small scale, we have demonstrated that we can purify water to the 1985 EPA standards. We are working now with the Environmental Protection Agency to build a bigger pilot plant in California to demonstrate this system.

This approach becomes extremely important because in order to meet the standards nationwide the country would have to spend on the order of $100 billion. This way of doing it will be much more economical. It has a secondary advantage of not having to carry away as much solid waste which today's sewage plants have to release.

As Mr. Talcott pointed out, it is a long way from the stars to the sewers but we are working on both ends of the scale.

POTENTIAL OF HYDROGEN INJECTION SYSTEM FOR GAS ECONOMY

Mr. BOLAND. Would you put the slide back to the automobile engine? You inject hydrogen into what?

Dr. LOW. Into the carburetor.

Mr. BOLAND. You are still going to burn gasoline?

Dr. LOW. The engine still burns gasoline but it burns less. Normally, in order to run an automobile smoothly, you have to burn a fuel mixture which is on the rich side—a little more fuel than air for the most efficient burning. When you inject hydrogen into the carburetor

in very small quantities, it turns out the engine will run smoothly and efficiently on the lean side of the curve—using less fuel and more air. The question becomes, where do you get the hydrogen?

SOURCE OF HYDROGEN FOR INJECTION SYSTEM

Mr. BOLAND. Isn't that a tough technical question?

Dr. LOW. It is not too tough. The people at JPL have found that the hydrogen can be made from the gasoline by a catalytic process. You split off a little gas, make hydrogen out of it and put it into the carburetor. You get the total efficiency and clean burning. It is lean and clean.

POTENTIAL FOR IMPROVED ECONOMY AND EFFICIENCY

Mr. YOUNG. And what is the cost? We use less gallons of gasoline, but how many gallons of gasoline do we use to create the hydrogen?

Dr. LOW. Still less than the total required now. The total balance is one of getting the efficiency back. The numbers I have seen is that we come close to meeting the EPA pollution-reduction standards, and yet the car would be back to what the same make and model car was able to get about 10 years ago in terms of gas consumption before the auto weights and environmental acessories increased. There is a potential for about a 20- to 30-percent fuel savings.

OUTLOOK ON APPLYING HYDROGEN INJECTION SYSTEM TO AUTOS

Mr. BOLAND. How far down the road are we looking here in terms of the possibility of using this type of combustion?

Dr. LOW. If it is accepted by the automobile industry, probably closer than with any other concept because it does not require retooling of the automobile industry. It uses the standard engines and adds a few items inside the engine compartment.

The hydrogen generator and new carburetor would be added to the top of the engine. If the automobile industry were to adopt a completely new engine, it would take them 10 years or more because they would have to retool, redesign, and retest. This hydrogen injection system could be done more quickly, perhaps within 5 years of acceptance.

AUTO INDUSTRY INTEREST IN HYDROGEN INJECTION SYSTEM

Mr. BOLAND. Is this the type of concept that the automobile industry would adopt?

Dr. LOW. They are interested in it. They were going to partially fund a study effort until they had their own financial problems. They are not funding it now. It certainly is one of the concepts that they are looking at.

NEED FOR LOW-COST HYDROGEN GENERATOR

Mr. BOLAND. It sounds so simple. Why wasn't this developed a long time ago?

Dr. FLETCHER. Mr. Chairman, a production hydrogen generator would be required, as Dr. Low explained. You would have to make a hydrogen generator that is compact, lightweight, and low cost.

We have one that is about the right weight, but we have to make it in such a fashion that it only costs an extra $100 or so. I think that is the main problem left to deal with in the years to come.

MASS PRODUCTION CONSIDERATIONS

Mr. TRAXLER. I think that is an important point.

The design has to be suitable for mass production. You do not want to add to the cost substantially.

I think, with the limited amount of technological training I have, I think I could design an engine that would burn cleaner and be more efficient—but in terms of mass production; no.

Dr. FLETCHER. The main advantage of this hydrogen injection system is that it would be a simple add-on to existing engines, whereas the other potential engines for higher efficiency would require retooling in the auto industry.

COST CONSIDERATIONS

Mr. TRAXLER. Simple add-ons have a way of increasing the cost substantially.

Mr. TALCOTT. Look at those engines. Right now the hydrogen trailer is bigger than the car in order to get hydrogen to use for this demonstration.

Dr. FLETCHER. That is only in the test car which is running now. The car with the hydrogen generator has not been in operation yet.

Mr. TALCOTT. So the efficiency you are developing here is just about equal to gasoline we already have, but the cost of the new generator that you and Mr. Traxler talked about is really going to raise the cost of the automobile and we have to consider the amortization costs. They maybe out of sight right now.

Dr. LOW. I am not sure that the hydrogen generator is as much of a development as the catalytic burner. Of course, you could do away with the catalytic burner if you had the generator instead.

POTENTIAL ADVANTAGES OF HYDROGEN INJECTION AUTO ENGINE

Mr. TRAXLER. We are interested because we realize the internal combustion uses 55 percent of the crude oil consumed in this country. If we could use the same engine block designs, the manufacturers would not have to go to R. & D. for new engines. If you could do that, I think there is a tradeoff there. Now that I review it, it sounds more interesting.

Dr. LOW. The manufacturers have to decide whether this system can be adopted, because they have to build and sell the cars. The potential for improved efficiency, decreased gas consumption, and reduced pollution looks promising.

Mr. TRAXLER. You are to be commended for ventures into this area.

Dr. Low. Mr. Chairman, I will wind up on the note of the budget (fig. 27).

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
BUDGET PLAN
(Millions of Dollars)

	FY 74	FY 75	FY 76	TRANSITION PERIOD (JUL 1-OCT 1, 1976)
MANNED SPACE FLIGHT	999.9	1110.3	1414.6	376.6
SPACE SCIENCE	664.5	542.8	582.6	160.3
APPLICATIONS	159.0	174.5	175.0	54.7
AERONAUTICS AND SPACE TECHNOLOGY	234.3	237.8	250.3	69.1
TRACKING AND DATA ACQUISITION	244.0	248.0	243.0	66.4
ENERGY PROGRAMS	4.7	4.4	5.9	1.5
TECHNOLOGY UTILIZATION	4.5	5.5	7.0	2.0
TOTAL RESEARCH AND DEVELOPMENT	2310.9	2323.3	2678.4	730.6
CONSTRUCTION OF FACILITIES	101.1	142.7	84.6	14.5
RESEARCH AND PROGRAM MANAGEMENT	744.0	765.2	776.0	213.8
TOTAL BUDGET PLAN	3156.0	3231.2	3539.0	958.9

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Figure 27

We have already talked about the total fiscal year 1976 budget request, which is $3,539 million and the $958,900,000 for the transition period. As we meet with the subcommittee over the next day or two, we will review our research and development, construction of facilities, and research and program management requirements for fiscal year 1976 and the transition period.

DECLINE IN NASA'S BUYING POWER AND EMPLOYMENT

I wanted to make one final point about NASA's total request in historical perspective (fig. 28).

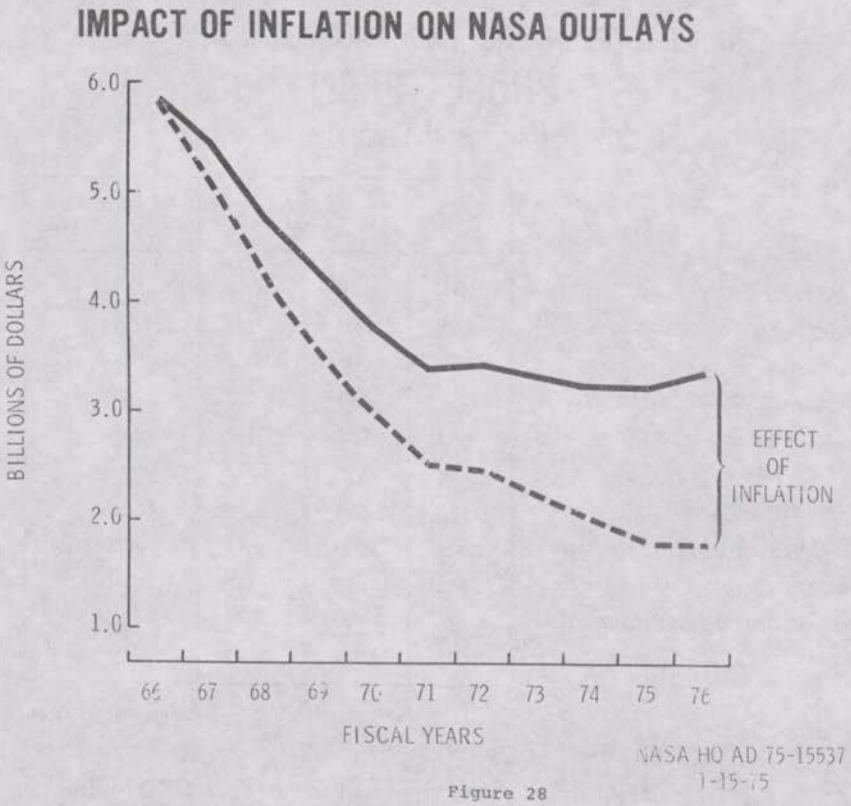


Figure 28

At the peak of the Apollo program spending, which occurred in fiscal year 1966, years before we first landed on the Moon, NASA's outlays were on the order of $6 billion. This was the peak NASA level. We came down rather rapidly after fiscal year 1966, as the Apollo Program funding drew to a close. In fiscal year 1970, we were down to a level of about $3.4 billion. Even though at that time we had planned to be at and hoped to stay at, this $3.4 billion level, plus provisions for inflation, the budget constraints intensified, and we were never quite able to reach a high enough budget level to compensate for the mounting inflation that has occurred since then.

So each year, year after year, because of these budget limitations, we had to cut back our programs and the spending that we had planned at the time of the "constant level" budget concept.

In terms of the number of civil service and contracted people employed in NASA programs, we have come down much more sharply than is indicated by the solid curve. Our peak was 420,000 people and by the end of fiscal year 1976, we will be down to 131,616.

In terms of actual spending power compared with the $6 billion at the peak of Apollo, our buying power is down to a third of what it was

in fiscal year 1966. We are down to about $2 billion in terms of comparable spending power. This is one-third of the peak spending level.

As you pointed out, Mr. Chairman, there is a tremendous economic impact from the Nation's space program. There is a huge benefit back into the economy in terms of payback from the technology that springs from the money invested in NASA. At a minimum, there are indications that there is a $7 return for every $1 invested in NASA's programs.

We believe that the programs we have, the programs I have described, do this in a very efficient way and provide the down-to-Earth benefits, the technology and the productivity that are essential for a viable economy.

Mr. BOLAND. Dr. Low, thank you very much for a very interesting and fine explanation of the programs. This committee will recess until 1:30.

AFTERNOON SESSION

Mr. SHIPLEY. The committee will come to order.

As I understand, you have completed your statement.

Dr. FLETCHER. Yes, sir, we have.

PEAK YEARS OF SHUTTLE FUNDING

Mr. SHIPLEY. I would like to make a brief statement and have your response.

The peak years of the Shuttle funding are here. The Shuttle is up $400 million above 1975. The total NASA funding is about $307 million. That means the Shuttle is cutting into other NASA programs. Do you feel that you have too many dollars in the same basket?

Dr. FLETCHER. No, Mr. Chairman, we do not. This was the programed amount for the Shuttle. In fact, it is actually less than would be required for the Shuttle as projected in previous years.

In order to stay within our budget constraints and still keep the Shuttle on schedule, we had to make program adjustments—deletions and deferrals of about $45 million. This included removing some hardware from the Shuttle program. Of course, there are some offsetting events happening at the same time. The Apollo-Soyuz program is phasing out, and there is no money requested for that project in fiscal 1976. The Viking program is also phasing down.

The fiscal year 1976 and fiscal year 1977 Space Shuttle requirements represent the peak years of funding for the program.

SHUTTLE ECONOMICS/DOD REQUIREMENTS

Mr. SHIPLEY. The Shuttle is the heart of the space program, and this committee has consistently supported development of the Shuttle. It will begin to make space flight routine. It is the next logical step into space. But the Shuttle has also been justified on the basis of economics. We have been told again and again that it will be cheaper than conventional boosters. Obviously, this argument rests largely on the number of payloads that will be launched. I would like to read you a few lines from an article in the December 1974 issue of Science magazine.

Nonetheless, opponents of the Shuttle argue that the volume of space traffic in the 1980's is unlikely to be large enough to justify the Shuttle's cost, even including the military applications that now appear to be its main raison d'être. It is widely acknowledged in military circles, moreover, that the Shuttle will not reduce defense costs substantially. The Shuttle is vulnerable to attack, because the five orbiting vehicles and two landing sites could be quickly destroyed, so that the Defense Department will continue to stockpile enough rockets to launch spy satellites and other hardware without it.

Since DOD payloads will comprise about 40 percent of the total Shuttle's usage, I would like your reaction to this statement.

Dr. FLETCHER. The statement is a rather long one. I did happen to read that statement.

Mr. SHIPLEY. I was sure that you would have.

Dr. FLETCHER. There are several aspects of that statement that need to be clarified. The first is the allegation that the number of flights per year would not be enough to justify the Shuttle.

Actually, we could get a 10-percent return on investment, according to the economic benefits analysis, with only 25 Shuttle flights per year. Twenty-five flights per year is actually less than NASA is planning to fly in 1975. NASA alone is planning 28 launches in 1975. This does not include any military flights at all. So it is a little misleading in that article to say that there are not enough flights to justify the benefits of the Shuttle.

The second part addressed the military use of the Shuttle only. I have understood that there is concern about the hardness of the launch site for military use of the Shuttle. I am not an expert on the military uses of the Shuttle.

I do want to say, though, that from the very beginning the Defense Department has worked with NASA in establishing the Shuttle requirements. There is a joint NASA–DOD Space Transportation System Committee which assures that the Space Shuttle meets the needs of both agencies. The Shuttle is designed to fit their needs, and they do plan to use it approximately as indicated in our payload mission model. I think the "40 percent per year" statement might be a little high. As I recall, DOD is more like 30 percent of the payload program included in the 1973 mission model. But I would not quibble about the difference.

SHUTTLE ECONOMICS

Mr. SHIPLEY. I want to read, too, Doctor, from the U.S. General Accounting Office staff study of the space transportation system, dated February 1975. I quote from page 8. It says:

Their design of military satellites is currently limited to configurations which can also be launched with the available expendable vehicles until sufficient STS flight experience is available to warrant complete reliance on the STS system. In this regard, all the currently planned satellites could be launched with present expendable boosters.

What do you have to say to that?

Dr. FLETCHER. I can start and Dr. Low may want to pursue that point further. The Air Force has felt that they ought to design their payloads to go either way, with expendable launch vehicles or with the Shuttle. The Shuttle development, of course, is not under their control. It is NASA's responsibility to develop the Shuttle. So they have designed their payloads so that they could be launched by either

the Shuttle or by expendable launch vehicles. However, the Air Force, it is my understanding, has underway a very comprehensive study on how their payloads might be redesigned to take full use of the Shuttle capabilities. The Air Force is also studying what new payloads might be developed that require the unique capabilities of the Shuttle and could not be flown on expendable vehicles.

DEPARTMENT OF DEFENSE COMMITMENT

Mr. SHIPLEY. To quote further, last paragraph, same page:

U.S. Air Force officials advised us that there is yet no agreement between DOD and NASA as whether DOD will buy two of the five orbiters. The orbiter procurement decision has been deferred by DOD; therefore, the Air Force has been directed not to include funds for this purpose in their budget.

Dr. LOW. Mr. Shipley, the DOD, the Air Force, has committed to use the Shuttle for their purposes. DOD has committed to develop the interim upper stage for the Shuttle. DOD has also committed to provide the west coast Shuttle launch facilities at Vandenberg Air Force Base. DOD has not yet had to make a decision on funding the procurement of two orbiters because the initial funding for these two orbiters is not required until fiscal year 1978.

So the statement is correct, except that it does not recognize that the procurement of these two orbiters is a future year's budget decision. However, DOD has made a firm commitment that they will use the Shuttle for their purposes.

They have committed those funds which they must commit now for the interim upper stage and the Vandenberg Shuttle launch site development to get started and be ready for the Shuttle operations.

Mr. YOUNG. Mr. Chairman.

Mr. SHIPLEY. Yes, Mr. Young.

EAST AND WEST COAST SHUTTLE LAUNCH SITES

Mr. YOUNG. Did you say the Shuttle will be launched from Vandenberg?

Dr. LOW. The Shuttle will have two launch sites, Kennedy Space Center on the east coast and Vandenberg on the west coast. For those launches which go in an easterly direction, the Shuttle will be launched from Kennedy Space Center. For launches which will carry an upper stage to achieve synchronous orbit, the Shuttle will be launched from Kennedy Space Center. For launches which go north and south, the Shuttle must be launched from Vandenberg because those types of launches from Kennedy Space Center would involve an overflight of land masses.

Mr. YOUNG. You need the water for recovery?

Dr. LOW. Yes. You can do that from both. About 60 percent of the launches will go from the east coast and 40 percent from the west coast.

Mr. YOUNG. Of course, I did not take a parochial interest, but I understood that a water area was necessary for recovery of the solid rocket boosters.

Dr. LOW. That is correct, Mr. Young.

Mr. YOUNG. If you are going to launch in an easterly direction, from Kennedy Space Center and north and south from Vandenberg you would not have a lot of water.

Dr. LOW. That is right.

Mr. YOUNG. That is the reason I asked the question. The fact that Florida has water on its eastern side is an added benefit.

Mr. TALCOTT. The fact of the matter is that you need both launching sites.

SHUTTLE RETURN ON INVESTMENT

Mr. BOLAND. Can you give the committee your best estimate, strictly on the basis of economics, at what point the Shuttle begins to lose its viability? How many payloads have to be flown in the 1980 to 1991 period to warrant the $8 billion-plus cost of development, testing, et cetera?

Dr. FLETCHER. You can still get a 10-percent return on investment at the rate of 25 Shuttle launches per year. That is typical launches per year. It is actually less than the number of launches we plan this year, as Dr. Low indicated. I should add that a 10-percent return on investment is a high return for a noninflationary period. This is based on uninflated dollars. If you wanted a lower return on investment, you could stand an even lower number of launches or flights per year. You can have some ridiculously low launch numbers and still have a good return on investment.

VIABILITY WITHOUT DOD USE

Mr. BOLAND. Is the Shuttle still economically viable without any DOD use?

Dr. FLETCHER. Yes, Mr. Chairman, it would still be economically viable even without DOD use. I want to add that the Shuttle is designed for a wide variety of users, not only for DOD use and NASA use but also for the use of the entire free world. It should not be looked on as only a NASA transportation system. It will be used by many different domestic and international users.

SHUTTLE BENEFITS OVER EXPENDABLES

Mr. BOLAND. A dramatic illustration of the potential savings offered by the Shuttle is displayed in the July 31, 1974, issue of Space Digest. It indicates that the planned payloads through the period and their respective costs are: 507 NASA payloads, $17.6 billion; 175 non-NASA payloads, $5.1 billion; 304 DOD payloads at $9 billion, for total of $31.7 billion.

It also indicates that to launch the same 986 payloads, without the Shuttle, by conventional expendable boosters would cost an additional $14 billion. The net benefit gained from using the Shuttle represents a dramatic savings. But my questions are: Are the payload estimates correct, and don't you agree that the Shuttle's economic viability rests really on the willingness of Congress, year by year, to provide the $17.6 billion to finance the 507 NASA payloads?

Dr. FLETCHER. You asked two questions: First, are the payload estimates approximately correct? Those numbers represent our best

estimate as of that time. I would point out that the Congress must approve the payloads as part of our annual authorization and appropriations process. There is not any blanket approval of the whole payload program. This is only our estimate as to what the payloads will be through 1991. There will be many changes before that time, as we refine our payload planning. The answer to the second question: Is it an implicit commitment to NASA to pay for those 500 payloads, the answer is, "No."

It would be a mistake, in my judgment, to cut back on the space program, because those 500 payloads would be about the same level of expenditures as we are spending now. We could do it for the same level of funding that we are talking about now. So it would be a mistake not to take advantage of the opportunities offered by the Shuttle. However, the Shuttle is still economically viable at a lower density.

COST OF SHUTTLE

Mr. BOLAND. Last year you indicated, on page 38 of the hearings, that in constant 1971 dollars the cost of the Shuttle development is estimated at $5.2 billion compared with your original estimate of $5.15 billion; initial facilities, $300 million; initial investment, such as refurbishment of the first two orbiters and procurement of three additional orbiters, $1 billion; cost, including the tug, to fly the 581 mission model, $1.6 billion, for a total of $8.1 billion.

In constant 1971 dollars, have any of those numbers changed and what has been the cumulative effect of inflation on the total?

Dr. FLETCHER. Mr. Chairman, as I think we indicated last year, in terms of 1971 dollars, we did have to increase the estimate of the Shuttle D.D.T. & E. costs from $5.15 billion to $5.2 billion because of the schedule stretchout caused by OMB cuts in the fiscal 1975 budget. That is the only change in terms of 1971 dollars. So the estimate that you mentioned has increased by $50 million.

The best estimate in the dollars of the fiscal year 1976 budget would be about $10 billion.

INTERIM UPPER STAGE/SPACE TUG

Mr. BOLAND. Last year the committee explored carefully the issue of the interim upper stage. The interim upper stage will be paid for and built by the Air Force. It will be used from 1980 to 1983 until a NASA-developed and funded full capability tug is ready. I think you have already agreed that without the tug the Shuttle is not completely viable because about 40 percent of all payloads must be lifted to high orbits.

Last year you estimated that the interim upper stage would cost the Air Force about $100 million. Will the Air Force have the interim upper stage ready in 1980 when the Shuttle becomes operational and can you depend on that?

Dr. FLETCHER. The Air Force is planning to develop the interim upper stage. Their current estimate for that is between $40 million and $100 million, depending on the study results. We are confident that the interim upper stage will be available for use with the Shuttle

in the 1980 period. Therefore, for all the higher orbits, such as synchronous, an upper stage will be available when needed.

INTERIM UPPER STAGE COST ESTIMATE

Mr. BOLAND. And the $100 million estimate is still accurate?

Dr. FLETCHER. That is an upper bound, Mr. Chairman. They may actually come in with a cost estimate less than $100 million. The current estimate is $40 million to $100 million, depending on the study results.

PURPOSE OF SPACE TUG

Mr. TRAXLER. Mr. Chairman, for my benefit could Dr. Fletcher tell me a little about the tug?

Dr. FLETCHER. The Space Shuttle itself, will carry payloads or spacecraft up to about a 100 to 200 nautical mile orbit. To get up to the higher orbits, you need an upper stage. An upper stage, an interim upper stage or a reusable space tug, will be carried in the Shuttle's cargo bay. Once in orbit, it will be separated out of the payload compartment and ignited to take the payload into the appropirate orbit.

The upper stage device that we are talking about is either the interim upper stage or, ultimately, the space tug.

Mr. TRAXLER. Is that recoverable?

Dr. FLETCHER. The full-scale tug is a fully recoverable tug. The interim upper stage that the Air Force is developing will probably not be recoverable.

Mr. YOUNG. Mr. Chairman.

Mr. BOLAND. Yes.

TUG OPERATIONS

Mr. YOUNG. The NASA tug, your final version actually will be recoverable by the Shuttle, will it not?

Dr. FLETCHER. Yes.

Mr. YOUNG. The tug reaches a synchronous orbit and it reaches up and grabs the payload and pulls it back down.

Dr. FLETCHER. Yes. For very high space orbits that will be true. The tug will take off and deliver its payload to the 22,000-mile orbit and return to the Shuttle. The tug will be put in the payload bay and then the Shuttle will bring the whole works back to Earth.

There will be cases where the tug will be intentionally expended and that is for flights out beyond the 22,000 miles, say to the Moon or one of the planets. In those cases, for automated lunar and planetary missions, the tug would not be retrieved.

FEASIBILITY OF MANNED TUG

Mr. YOUNG. In that case, the tug is not manned. But in a reusable situation will the tug be manned, or can it be manned?

Dr. FLETCHER. The present near-term plan is that the tug not be manned. It will be automatic. We do plan a small study effort in fiscal year 1976 to examine the feasibility and possibility of adding a crew module to the tug for geosynchronous operations.

Mr. YOUNG. Will it be large enough to be manned if you should make that decision?

Dr. FLETCHER. There is no present requirement for a manned tug. It would be an interesting possibility, though.

SHUTTLE/TUG REPAIR CAPABILITY

Mr. YOUNG. In addition to the tug placing a payload into synchronous orbit or wherever you might place it, could the tug be used for repairs of a satellite already in orbit or even for maintenance or protection?

Dr. FLETCHER. Yes, sir. That is the plan. Refurbishing would be the easiest thing—take out a part and replace it. To go in and repair wires automatically becomes difficult. The chances are that the tug would bring the payload back to the Shuttle, where it would be repaired. Then the tug would return the payload to orbit for continued operations.

Mr. YOUNG. The possibilities are almost unlimited as to having that Shuttle platform in orbit.

Dr. FLETCHER. That is correct.

Mr. YOUNG. Thank you.

VIKING COST CHRONOLOGY

Mr. BOLAND. The committee's fiscal year 1975 report specifically denied any reprograming of fiscal year 1975 funds for Viking. In the meantime, NASA has reprogramed $48 million of fiscal year 1974 funds to this program. Cost overruns caused by development difficulties and inflation have increased the cost estimate of this program from $364 million to about $950 million; is that correct?

Mr. LILLY. The $364 million figure was a very preliminary planning estimate done in 1968 in the early planning phase, before we moved very far along in terms of firmly defining the program.

In 1969, after the original prime contract was signed and we had better insight into the possible cost, one estimate was $711 million. In December 1969, because of funding constraints we had to slip the schedule from 1973 to 1975, 2 years. As a result, the cost was estimated as $700 to $850 million. That estimated cost was provided to the Congress in 1970. As you stated, Mr. Chairman, the current estimate is a top boundary of $950 million for the Viking program.

COMPLEXITY OF VIKING

Mr. BOLAND. Would the Viking be an example of your pushing the technological state-of-the-art too quickly, resulting in the dramatic increase in costs?

Dr. FLETCHER. The Viking program started before I arrived at NASA. In my opinion, it was an extremely ambitious undertaking, with tremendous potential. The potential returns were extremely large. It is NASA's most ambitious attempt at landing a highly sophisticated, automated spacecraft on another planet. That is hard enough as it is, but we also decided to put a full-flledged biological laboratory on the Viking, as well as a geophysics laboratory to investigate the geology of Mars, a weather observatory, and a chemical laboratory. All of these are compacted into a rather small volume. It is an ex-

tremely difficult undertaking, but it looks as though we are going to make it. At the present time, it looks as though all of these laboratories are working and ready.

VIKING COSTS UNDER CONTROL

Mr. BOLAND. Are the costs now under control?

Dr. PETRONE. I have been giving that my personal attention. I would say, "Yes." When we reported to your committee in October on reprograming, we told you what we were going to do. We have maintained that plan. We have delivered the hardware to the Cape for launch, and we are meeting our schedules within costs for an August launch.

VIKING LAUNCH WINDOW

Mr. BOLAND. The launches are scheduled for August of this year?

Dr. PETRONE. Yes. We have about a 40-day window.

Mr. BOLAND. Will you explain to the members what a launch window is?

Dr. PETRONE. There is a limited launch opportunity every 25 months because of the energy available from the launch vehicle that will propel the spacecraft. In order to reach Mars, we have a 40-day period of time when the position of planets, Earth versus Mars, are correctly alined for the Titan-Centaur launch vehicle to deliver sufficient velocity to the spacecraft to intercept Mars in the summer of next year; 10 months later.

If you miss that window, that 40-day opportunity, you have to wait 25 more months before you can launch again.

It would be very costly to keep the contractor and science teams together.

VIKING EXPERIMENTS

Mr. BOLAND. Will all the planned experiments be intact?

Dr. PETRONE. At this time, I can report to you that each one of the 13 experiments planned is viable. We still have a number of months of checkout before launching in August. As of today, we plan to deliver the biological package to the Cape in mid-March. Today we do plan to have all experiments on board that we had planned a year or two ago.

VIKING LAUNCH WINDOW

Mr. TALCOTT. Mr. Chairman, may I ask, did we miss one window on Mars?

Dr. PETRONE. Initially this program was set up for a 1973 window. During the formulation of the fiscal year 1971 budget, in December 1969, financial constraints resulted in a decision to delay the launches 2 years. That schedule stretchout also drove the cost approximately $120 million upward.

Mr. TALCOTT. This gave you an opportunity to develop the labs that you are going to have on board and the original Viking proposal did not include that. You were just going to go to Mars, scoop up some stuff like you did on the Moon and bring it back?

Dr. PETRONE. Not bring it back, sir. In the Viking program we had never planned the return of samples from Mars. We always planned to

conduct these experiments on the surface of the planet. The degree of sophistication has increased over the initial plan, but we never planned return of samples. The slip of 2 years primarily allowed us to further refine the experiments, but the basic experiment complement did not change from the 1973 mission plan to the 1975 plan.

DIFFERENCE BETWEEN VIKING AND APOLLO

Mr. TALCOTT. Why did the Viking proposal have the labs on board as compared with the early Moon experiments where you brought the materials back to Earth and did the experimentation or research on the samples in Earth labs which are a lot more sophisticated than an automated one on Mars?

Dr. PETRONE. Bringing a sample back would have resulted in a much more costly program. Hopefully, in years ahead, by combining the tug with the Shuttle, we will be able to bring a sample back. But with our present technology and present methods, it would have been a much more costly program than Viking.

Dr. LOW. In the Apollo program, the men were, of course, brought back so it was economical to bring the samples back along with the men. In Viking, we do not have people to bring back, so it is cheaper to operate the biological lab on the surface.

Mr. TALCOTT. People are asking me why not bring it back and do a more sophisticated job of analysis here on Earth.

Dr. LOW. It would cost far more than the Viking program to develop a capability to bring samples back from Mars.

Dr. FLETCHER. It is a good idea to think about it for the future, however.

Dr. LOW. Viking's cost history is certainly not representative of NASA's record. Looking at the history, the numbers that I have, the cost estimate before we slipped from a 1973 launch to a 1975 launch was $711 million. That was the cost estimate we had in October of 1969. In December 1969, we slipped the program 2 years because of financial constraints. Schedule stretchouts always cause major increases in program cost.

When we reported to the Congress in March 1970, we gave an upper limit of $850 million, just as a result of the slip from one launch window to the next. That estimate held for about 3 years. Then we had technical problems. Since that time, we have had an increase of about $100 million. So the only real overrun in the program was that last $100 million, caused by technical problems and inflation. As I said before, by NASA's standards and record, we try to do much better; but in the overall sense of the history of R. & D. programs in this country, it is not all that bad.

Mr. TALCOTT. May I ask a couple of questions?

First of all, I would like to commend you, Dr. Fletcher, on the presentation we have had here today. I think it has been very helpful.

RETURNS FROM SPACE PROGRAM

The NASA program has been one of our bright lights, I think, in the Federal bureaucracy. It seems to me that this is a program that is of absolute necessity for research, testing and development. There is a tremendous return that we are beginning to see.

You know, space really has come of age just about now. When we had the lunar program we were still sort of experimenting with research, development and testing. Now we are beginning to get some productivity and some use here on Earth. This, it seems to me, is when a program matures and comes of age. I think we should be celebrating this year now perhaps as much as we did when we first landed a man on the Moon and brought him back safely.

I think we should be extremely grateful for the returns we are getting, economically, socially, and technically, in addition to the public relations and the prestige that our Government, our scientists and technologists are receiving.

The joint Soviet-United States manned space venture is just one area in this program. I think one of the most important contributions of NASA is the system of getting things done that we have developed. Unfortunately, this is one of the applications that you are not sharing enough with other governmental agencies. If we could only apply your systems program to HUD and HEW and some of these other agencies and the military. The Government really needs your systems approach as well as your technology advancements.

So I want to commend you for all these things.

OPPORTUNITIES AND CHOICES IN SPACE SCIENCE

There is one area that has concerned our committee. This is with telescopes. Between your agency and a number of others, we have had at least half a billion dollars worth of requests for telescopes. Of course, your agency is the one that has caused all the interst in astronomy. There is a publication entitled "Opportunities and Choices in Space Science," by the National Academy of Sciences. Have you had an opportunity to review this?

Dr. FLETCHER. Yes.

Mr. TALCOTT. For the record, I would like to have your views on this report.

First, Mr. Chairman, I would like to ask unanimous consent that this be placed in the record. I think it is a very valuable document.

Mr. SHIPLEY. I think it would be all right.

[The information follows:]

1
Purpose of the Report

The Space Science Board last made an overall assessment of the National Aeronautics and Space Administration's space-science program in 1970.* Four years later, the major recommendations of that report are in the course of implementation (see, however, Chapter 3, Section I). Other findings and recommendations of the report are rendered obsolete either by program developments such as the Space Shuttle or by new scientific discoveries. The impetus of the 1970 study has therefore been spent, and in the absence of a new study the Board lacks a substantial basis for advice to NASA where this advice involves interdisciplinary priorities, long-term strategy, or other matters that require a level of consensus in the scientific community.

At the 48th meeting of the Space Science Board held on February 7-8, 1974, the Board recommended that a new study be undertaken. Funds were not available for an extensive "summer study" activity, and the Board decided to try an experimental approach based on work by its disciplinary committees and consultation with a segment of the profession by mail.

The study was carried out in the following stages:

**Priorities for Space Research 1971-1980* (National Academy of Sciences, Washington, D.C., 1971).

1. The planning wedge* in current use by the Office of Space Sciences (OSS) was adopted as a constraint on the funding available for new projects.

2. By agreement with disciplinary committee chairmen, planning wedges for the individual disciplines were allocated in order to illuminate the necessary choices. For planning purposes, 50 percent and 100 percent of (1) were allocated for each of the Committees on Space Astronomy and on Planetary and Lunar Exploration (the Committee on Space Astronomy also opted to investigate a 67 percent planning wedge); and 10 percent of (1) was allocated for the Committee on Space Physics.

3. Each disciplinary committee wrote a preliminary report for circulation to other active scientists. One hundred and twenty written replies were received, about forty in each discipline. These replies constitute a unique documentary resource for the Board.

4. On the basis of these replies, the disciplinary committees identified controversial areas and invited to their deliberations scientists who could speak for these areas. The Committee on Planetary and Lunar Exploration also sponsored, at the request of NASA, a special study on the future exploration of Mars, within the framework of the overall planetary and lunar priorities.

The working papers from these activities are printed, without modification, as Part II of this report.

5. On October 10-12, 1974, the Space Science Board examined these reports with particular attention to (a) general strategy, (b) interdisciplinary funding conflicts, (c) rationale for the new starts proposed for fiscal years 1976 and 1977, and (d) special problems.

The results of our study constitute Part I of this report.

*The planning wedge is the annual funding available for new projects. It is derived by summing (for each succeeding fiscal year) the estimated costs for the completion of all existing projects and subtracting the totals so derived from the expected fiscal year funding for research and development. It is a wedge (with its sharp edge in the next fiscal year) because the R&D funding for space sicence is expected to remain constant during the near term, while the runout costs of existing projects decrease with time. Hence the funds available for new projects increase with time, as a wedge increases thickness when one moves away from the leading edge.

Our report deals only with the program of the Office of Space Science. The Board is also concerned with space biology and medicine, funded principally by NASA's Office of Manned Space Flight, and the scientific basis of applications programs, funded by NASA's Office of Applications. In future years, the Board hopes to put increased effort into both of these areas. The annual report of the Committee on Space Biology and Medicine, accepted by the Board, is included in Part II.

An important consequence of an intensive study is that the Board gains a depth of familiarity with both the problems of NASA and the views of the scientific community. We have already pointed out that such expertise rarely has a lifetime of more than three to four years and therefore must be renewed at regular intervals. We have, therefore, concluded that it will be economical of effort, and our advice will be of greater value, if this study is updated year by year.

2
Strategies for Space Science

I. STRATEGY FOR SPACE PHYSICS

Space physics concerns interactions in space among energetic charged particles, ionized plasmas, and magnetic and electric fields. Most of the investigations are conducted in the ionosphere and magnetosphere of the earth, because of its accessibility. The interplanetary medium and the atmospheres of the other planets are of strong ancillary interest. In spite of the tenuous nature of matter in these regions, the complex physical processes that they exhibit are of fundamental importance to many of man's activities, both practical (e.g., long-distance radio communication) and scientific (e.g., study of plasma physics and astrophysics).

Knowledge of space physics has advanced rapidly in the more than a decade of exploration using space vehicles. The fundamental remaining questions are now much better defined. Some examples are

1. How does the solar wind flow into the earth's magnetosphere?
2. What are the mechanisms of coupling between the ionosphere and magnetosphere?
3. What are the mechanisms for generating nonthermal radiation from the magnetosphere?

The solutions to such problems require coordinated attacks not possible in the past because of the lack of adequate information and suitable technology.

What is needed now are carefully planned missions in which the important parameters (e.g., dc magnetic and electric fields, waves,

energetic particle flux, thermal plasma properties) are measured simultaneously in the ionosphere and magnetosphere at several points chosen to identify or isolate particular physical phenomena. Rapid data handling and exchange of data between investigators are needed to permit quick reaction to the results of each experiment. Individual experiments can then be turned on and off or have their parameters modified by command from the ground to maximize the scientific output during the next experiment opportunity. New propulsion systems permit changes in orbits that are needed to bring about favorable relative positions of satellites. Active experiments involving injection of waves and particles into the magnetosphere permit a degree of control approaching that achievable in laboratory experimentation.

Much of space-physics research is done near earth. The instrumentation needed is well developed and does not place difficult requirements on space vehicles. Hence, the cost of space-physics research in the terrestrial environs is low by comparison with space projects in general. Its relative simplicity and low cost make this type of space research particularly well suited for cooperative international efforts for which each nation supports the activities of its own scientists. Also, associated with the modest spacecraft and instrumentation costs, there are larger numbers of scientists involved than would be assumed on the basis of the total cost of the space-physics program and a correspondingly high scientific productivity per unit cost.

Continuity of effort in the proposed program in space physics is achieved by alternating in succeeding 3-year intervals the launching of Electrodynamic Satellites with Atmospheric Explorers. The purpose is to maximize the number of active spacecraft that can contribute to coordinated measurements while limiting total expenditures for space physics and maintaining them at a relatively even level.

II. STRATEGY FOR SPACE ASTRONOMY

The goal of space astronomy is to operate *permanent* observatories in space. The Space Shuttle provides the capability to deploy, maintain, and repair them while in orbit. The Space Shuttle is also required to return the observatories to earth for major refurbishment and updating. The strategy is similar to that which has proven successful for ground-based astronomy. Following the pattern set by the Kitt Peak

National Observatory (KPNO), the Cerro Tololo Inter-American Observatory (CTIO), and the National Radio Astronomy Observatory (NRAO), we envisaged analogous national or international observatories in orbit.

The first of these observatories is the Large Space Telescope (LST). Historically the LST has evolved as a 3-m diffraction-limited (0.03 sec of arc resolution) telescope. However, it appears that an instrument in the 2-m class (perhaps 2.4 m) having a resolution of 0.10 sec of arc can be built at substantially less cost than the full performance 3-m instrument. Although the faintest star observable is about three times brighter (about 1 magnitude) than the 3-m LST, the 2.4-m telescope would be a magnificent instrument, capable of making many critical observations relevant to extragalactic research and cosmology. It could observe stars ten times fainter than is possible using ideal detectors on the largest ground-based telescopes. Moreover, it would have ten times sharper resolution. As a result, the fraction of the universe that can be observed with precision would increase 30 times.

Another permanent observatory that receives high priority contains a 1.2-m imaging x-ray telescope. This orbiting observatory will have the versatility to observe a wide variety of objects ranging from the nearby x-ray stars to galaxies in the farthest reaches of the universe. Like the LST, this national x-ray observatory has been planned in detail.

Eventually, we envisage other permanent observatories operating at gamma-ray wavelengths, infrared wavelengths, and radio wavelengths. We also foresee permanent solar and cosmic-ray observatories in orbit. A series of smaller free-flying and Shuttleborne instruments must precede these permanent observatories, however, as the Orbiting Astronomical Observatory (OAO) and High Energy Astronomical Observatory (HEAO) satellites precede the LST and the large x-ray telescope.

III. STRATEGY FOR PLANETARY AND LUNAR EXPLORATION

The goals of planetary exploration for the next two decades are to conduct broad-based exploratory studies of the full range of bodies in the solar system, to extend our knowledge in a diverse way beyond the moon and Mars, and to gather new data obtainable from probes and orbiters. The logical sequence of investigation of a plan-

etary body should proceed via reconnaissance, exploration, and detailed study, in which discoveries in one mission help to shape the scientific objectives of the next. The strategy for planetary exploration should involve a balanced approach to all accessible objects in the solar system and should include all pertinent disciplines. The attainment of balance is a goal that can only be achieved over a decade; from time to time it is opportune to emphasize the investigation of certain objects, depending on flight opportunities and technological developments.

During the past seven years there have been major accelerations in the investigations of the moon and Mars beyond the logical exploratory sequence, culminating in sample return from the moon and the imminent biological investigation of Mars. Unless there is a positive indication of life on Mars, the continuing investigation of these bodies should emphasize global geochemical and geophysical surveys as a medium-term policy. Such surveys are complementary to the investigations of returned lunar samples and will help in the selection of optimum landing sites for future Mars sample return.

The inner planets, Venus and Mercury, have been objects of substantial mystery until the recent Mariner Venus Mercury reconnaissance. This relative neglect should be rectified in the medium term by orbital surveys: Pioneer Venus '78 for atmospheric and ionospheric study, imaging radar for mapping the Venus surface, and a chemical and physical study of Mercury.

The richness of the phenomena seen in the Pioneer 10 mission highlights the importance of a period of continuing emphasis on the outer planets through the middle 1980's, beginning with the ongoing Pioneer and the scheduled Mariner Jupiter Saturn missions. This emphasis is appropriate because a period of favorable flight opportunity coincides with the advent of our ability to assemble spacecraft with the needed performance. It is possible to carry out the preliminary reconnaissance of Saturn and Uranus during this period and to commence the detailed study of the Jovian system. The Jupiter orbiting missions have the potential for an immensely rich return of valuable scientific data concerning particles and fields; the composition, structure, and meteorology of the Jovian atmosphere; and the detailed properties of the regular satellites. The timing of these missions is critically dependent on the state of propulsion technology.

Cometary investigation by spacecraft has yet to be undertaken, and one may contemplate a ballistic intercept mission in the 1980

51-423 O - 75 - 6

time frame, to be followed a few years later by a rendezvous mission. The latter will require the development of solar-electric propulsion, a technology that will also be essential for missions to investigate planets beyond Uranus as well as asteroids.

The ultimate objective of planetary investigations should be to return samples for detailed study in terrestrial laboratories. This has been accomplished for the moon, and the Space Science Board recommends that sample return be considered the long-term goal for Martian exploration. These samples will be of high exobiological as well as geophysical and geochemical interest.

Existing fiscal constraints prevent an optimum pacing of these exploratory activities, and the mission model described in this report responds to these constraints through postponement of some of the missions to later years. If choices must be made among recommended missions, they should preserve the relative emphasis given in the mission model.

3
Findings and Recommendations

I. APPROVED PROGRAMS

Three major approved programs in space science represent the next opportunities for important advances in space astronomy and in planetary and lunar exploration, namely, High-Energy Astronomy Observatories A, B, and C; Pioneer Venus; and Mariner Jupiter Saturn. All three programs have been slipped in time and restructured with considerable effort, sometimes more than once, in order to achieve minimum cost and optimum science output. Each has been evolved as the result of lengthy efforts by a substantial scientific community largely external to NASA; the scientific justification for each has been refined and tested to the extent feasible. Finally, these programs are NASA's main response to the recommendations of the 1970 study of the Space Science Board (*Priorities for Space Research 1971–1980*), and their implementation will be the tangible result of several years of interaction between the Board and the space agency.

The Board wishes to reiterate its strong support for these missions. We are aware that in times of fiscal stringency even approved programs are at risk. These three programs, however, are of such standing that their implementation must be given highest priority on an agency-wide basis if there is to be a viable, quality program in space science.

II. RECOMMENDED MISSION MODEL

Table 1 combines the most carefully refined mission models submitted by the disciplinary committees of the Board. The estimated total cost of these missions is close to, but somewhat larger than, the

TABLE 1 Model of Proposed Missions for Space Science

	New Starts		Near-Term Strategy					Long-Term Goals							Mission Totals
Fiscal Year:	76	77	78	79	80	81	82	83	84	85	86	87	88	89	
LUNAR AND PLANETARY															
Mercury															
Mariner Mercury orbiter	–	–	–	–	–	6	28	(99)							133
Venus															
Orbiting imaging radar	–	–	–	–	–	26	86	(93)							205
Moon															
LUNAR POLAR ORBITER		*4*	*13*	*13*	*9*	*2*	*1*								*42*
Mars															
VIKING EXTENSION	–	*10*	*10*	–	–	–	–								*20*
Mariner orbiter	–	–	–	11	32	62	28	(36)							169
Pioneer penetrator	–	–	–	–	–	–	7				(71)				78
Surface Sample Return	–	–	–	–	–	–	–							(1000)	1000
Jupiter/Uranus															
PIONEER JUPITER ORBITER WITH PROBE[b]	–	*6*	*29*	*43*	*51*	*26*	*4*		(17)						*176*
Mariner Jupiter orbiter	–	–	–	–	–	–	–				(278)				278
MARINER JUPITER URANUS[b]		*16*	*64*	*41*	*16*	*5*	*7*		(31)						*180*
Saturn															
Mariner orbiter	–	–	–	–	–	–	–		(282)						282
Comets															
Mariner Encke	–	–	5	27	34	15	–								81
Mariner Tempel II	–	–	–	–	–	–	–		(177)						177
ASTRONOMY															
Optical/ultraviolet															
LARGE SPACE TELESCOPE (2-m class)	*3*	*24*	*69*	*98*	*45*	*30*	*35*								*304*

Solar									
SOLAR MAXIMUM[c]		*9*	*23*	*16*	*9*	*8*	*10*		*75*
Sortie Instruments	–	–	–	2	10	10	10		32
Infrared									
SURVEY SATELLITE[d]		*2*	*12*	*23*	*6*	*2*	–		*45*
Cryogenic Telescope (1 m)	–	–	–	5	15	25	22		67
High Energy									
X-ray telescope (1.2 m)	–	–	2	5	10	25	25		67
GAMMA-RAY SATELLITE—100 MeV		*4*	*8*	*11*	*2*	*1*	–		*26*
Cosmic-ray and gamma-ray free-flyer	–	–	–	2	6	16	16		40
LAMAR (large-area x-ray) telescope	–	–	–	1	5	10	20		36
Sortie instrumentation	–	–	2	5	10	10	10		37
SPACE PHYSICS									
ELECTRODYNAMIC SATELLITES		*3*	*22*	*23*	*8*	*5*	*3*	*(1)*	*65*
Solar-wind Explorer	–	–	2	7	9	2	1	(1)	22
Atmospheric Explorer	–	–	4	21	19	5	4	(3)	56
AMPS (no cost figures available)									
Magnetospheric multiprobes	–	–	–	–	6	21	25	(8)	60
INTERDISCIPLINARY									
Out-of-the ecliptic	–	–	–	2	33	31	16	(11)	93
FY TOTALS (in FY 74 dollars)	3	78	265	356	335	341	358		
FY TOTALS (inflated)[e]	3	91	324	455	449	480	530		
OSS PLANNING WEDGE	3	113	247	396	400	490	580		
DIFFERENCE	0	22	–77	–59	–49	10	50		

[a] Conventional launch vehicle costs are included in mission figures where appropriate. Shuttle transportation costs are *not* included.
[b] See text for discussion of Mariner Jupiter Uranus and Pioneer Jupiter orbiter new start.
[c] See text for discussion of strategy recommended for solar astronomy.
[d] See text for discussion of strategy recommended for infrared astronomy.
[e] Assuming 5% annual inflation rate.

planning wedge presently adopted by NASA's Office of Space Science.

The Board has examined in detail the new starts proposed for fiscal years 1976 and 1977 and finds that each is well conceived and of first-class scientific importance. Details of these missions and their scientific rationale are to be found in Part II of this report.

The Board has further examined the near-term strategy represented by missions proposed for new starts for 1978 through 1982 and the long-term goals represented by new starts proposed for 1983 and later. This strategy and these goals are fully endorsed by the Board, with those reservations expressed below and in subsequent findings and recommendations.

We *recommend* that, fiscal constraints permitting, the new starts indicated in italics in Table 1 be undertaken in fiscal years 1976 and 1977 and that NASA adopt the near-term strategy and long-term goals indicated as a basis for future planning.

The Working Papers in Part II of the report contain additional mission recommendations, which have not been examined in detail by the Board but which could form the basis for an expanded program were the present funding constraints on the Office of Space Science to be alleviated.

The fiscal year 1976–1977 recommended new starts have funding patterns stretching over several years that exceed the OSS planning wedge in subsequent fiscal years. While the precision with which funding requirements can be estimated and the confidence one has in budgetary ceilings are both uncertain, the excess is substantial—$185 million—and illuminates a conflict that will have to be resolved at an early stage.

From the many options for stretching, slipping, and eliminating various missions, we identified four ways in which the excess could be eliminated:

1. Eliminate or slip for four years Lunar Polar Orbiter, Out-of-the-Ecliptic, Solar Maximum Mission, and Electrodynamic Satellites.
2. Slip the Large Space Telescope three years.
3. Slip Pioneer Jupiter Orbiter four years.
4. Eliminate Mariner Jupiter Uranus (slippage is not possible because of limited launch opportunity).

We reject option (1) on the ground that too much harm is done to too many programs. We favor a structured space-science program

involving a mixture of uniquely important large missions (e.g., LST), cost-effective major missions (e.g., Pioneer and Mariner), low-cost Explorers, ground-based observatories, and laboratory programs. We regard it as unwise to base a program on a few large missions at the expense of the foundations upon which they must be constructed. Our views are further articulated in Chapter 4. We are therefore unanimous in rejecting this solution to the funding problem.

We also reject option (2). The availability of the Space Shuttle has enhanced the Board's support for large permanent astronomical space observatories. In accordance with the views expressed in Section VI, below, we believe that the LST should be a 1976 new start.

The Board concludes, reluctantly, that two large new starts in the outer planets program are not consistent with the presently envisaged fiscal constraints placed on the agency. (See Section IX, below, for further findings.)

III. THE EXPLORER PROGRAM

Explorer satellites have a long record of achievement in space physics and astronomy. These relatively inexpensive spacecraft permit much faster reaction times than larger satellites, allow greater flexibility in planning, and provide more opportunities for international cooperation. Sometimes, somewhat larger spacecraft than those that can be launched on Scout rockets are included in the Explorer program; the Atmospheric Explorers constitute an example. The Explorer program is normally considered a level-of-effort program, currently running about $33 million per year, although increases above this level have at times been made to accommodate the occasionally larger program.

The Space Science Board has continually stated the importance of this program, which supports new astronomical initiatives and much of the terrestrial space-physics program.

We believe that, even within a level OSS budget, it is important to increase the Explorer budget to offset inflation and to build on the progress already achieved.

IV. OUT-OF-THE-ECLIPTIC MISSION

An out-of-the-ecliptic mission is supported by all three disciplines: space physics, space astronomy, and planetary and lunar exploration. The Board endorses the scientific rationale for this mission to expand our direct knowledge of the sun and interplanetary space from two

to three dimensions. We recognize that the solar wind, the interplanetary magnetic field, and the density of gas and dust are likely to be quite different away from the ecliptic. We also see an out-of-the-ecliptic mission as possibly providing direct access to nearby unmodulated cosmic rays, thus looking into interstellar space.

Although out-of-the-ecliptic missions are particularly attractive and have endorsement both from space physicists and space astronomers, more information is needed in order to establish their proper priority. A study of methods of achieving highly inclined orbits will indicate the extent to which solar-electric propulsion (SEP) can achieve solar latitudes more than 65° and the degree to which Jupiter encounters can provide the desired orbits.

If it is practical to place large payloads in highly inclined orbits, several new types of observation become possible: a polar view of solar features (e.g., solar streamers) could be obtained, and observations of very faint objects in the universe (e.g., extended wings of galaxies) should be facilitated by virtue of the reduced sky background. Much of the sky background in earth orbits is due to zodiacal light, i.e., sunlight scattered off dust particles concentrated in the ecliptic plane. Finally, the plasma frequency may be much reduced, thereby allowing radio-astronomical observations of the universe at much lower frequencies than is possible in the ecliptic plane.

We conclude that more comparative studies of Jupiter encounters and SEP should be made with respect to this mission so that the Board can better assess scientific output in relation to cost for these two alternative means of achieving high-inclination orbits.

V. SOLAR ASTRONOMY

Solar astronomy is an active discipline in which many important problems are being attacked. A large quantity of exceedingly valuable data was obtained from the Apollo Telescope Mount (ATM) on Skylab. The Solar Maximum Mission (SMM) is designed to move forward from the base provided by Skylab, taking particular advantage of the increased opportunities to observe flare phenomena near solar maximum.

Skylab ATM imagery combined with high spectral resolution has produced fundamentally new information on the structure of the solar atmosphere and its dynamical processes and the characteristics of solar flares. SMM is an appropriate transition from Skylab to Shuttle-supported operations, since it has the desired compatibility

with Shuttle refurbishment operations. Its instrumentation should exceed substantially the performance of ATM in temporal resolution of spectral and spatial variations. Instrumentation is available for high-speed spectroscopy, and TV imagery can be adapted from systems already developed for other space programs such as the Earth Resources Technology Satellite (ERTS). With these capabilities it seems assured that SMM will markedly improve our understanding of solar flares and other plasma-physics phenomena revealed in solar activity.

Coupled to laboratory studies of laser-beam-generated, high-temperature plasmas, the study of solar plasma behavior should contribute to progress in fundamental plasma physics.

Priorities for solar astronomy cannot be assigned from a single point of view. The sun is the only star that we can observe in detail, and it is the dominant source of thermal and chemical energy for the earth, with all that this implies with respect to problems of agriculture, energy, climate, and other areas of environmental concern.

We conclude that it is time to assemble a group of scientists to review progress being made in solving the major problems of the sun, both in relation to fundamentals of astronomy and to terrestrial interactions, and to recommend priorities for instrumentation and mission objectives. The study group should include not only solar astronomers but also workers in related areas such as particles and fields, interplanetary physics, the magnetosphere, the ionosphere, and meteorology. It should also contain some nonsolar astronomers, particularly stellar astronomers. This review should precede the final structuring of the SMM.

VI. THE LARGE SPACE TELESCOPE

The Space Science Board strongly endorses the Large Space Telescope (LST) as a new start in fiscal year 1976. A space telescope in the 2- or 3-m class will be an exciting major step in the history of observational astronomy, observational cosmology, and the understanding of the universe. While we recognize the desirability of a 3-m telescope, fiscal considerations appear to limit us to an instrument of the 2-m class. Such an instrument will represent an order-of-magnitude increase in capability over the best existing ground-based telescopes and can accomplish most of the science anticipated from the 3-m instrument, with only an increase of observing time.

The long lifetimes anticipated for LST and for other permanent observatories proposed for space astronomy draw attention to the institutions that will be needed to ensure their proper use. The LST will probably need ground-support facilities comparable with or larger than those of existing national observatories. Creating such facilities raises many problems, the most immediate of which will be competent staffing. While we intend to keep this matter under review, it should also be the concern of bodies representing the astronomical community.

VII. INFRARED AND MILLIMETER ASTRONOMY

The broad infrared spectral region between the few micrometer and 1-mm wavelengths is a realm rich for astronomy, which displays its own special phenomena and also sheds light on almost all aspects of astronomy. While there has been rapid and spectacular development of infrared astronomy in recent years, the absorption of much of this radiation by the earth's atmosphere necessitates work in space for its proper exploitation.

A survey satellite, which would detect infrared radiation from astronomical objects with adequate sensitivity and at a variety of wavelengths, is the logical first major step in infrared space astronomy. In order to clarify the appropriate strategy and timing for such a survey promptly enough for a firm decision on a satellite mission, a study is recommended during the coming year that would examine the general design of such a mission and the state of development of the required technology and would compare the effectiveness and cost of alternative approaches to infrared astronomy. Aspects that should be examined in connection with the study of a survey satellite mission include

1. The quantitative comparison of a survey by satellite with surveys from the ground, from balloons, from rockets, and from airplanes such as NASA's C-141 observatory.

2. Possible increases in efficiency of the above methods of obtaining infrared observations by improvement of far-infrared detectors and by decrease of telescope radiation.

3. The state of technology for long-lived cryogenic cooling in space.

4. The efficiency and reliability of detectors for the very-long-wavelength infrared region and their likely rate of improvement.

The Board proposes that a study of goals and priorities in space infrared and millimeter astronomy be undertaken in 1975.

The Board's recommendation for a new start in fiscal year 1977 for an infrared survey satellite (see Section II, above) is conditional upon endorsement by such a study.

VIII. CONTINUING EXPLORATION OF MARS

The Viking 1976 Mars landers are designed to place a complex laboratory on the surface of the planet to perform *in situ* measurements on the soil and the atmosphere. At present, Viking mission planning provides a nominal 90-day postlanding period for operation of the surface and orbital experimental payloads. To cover operational costs and additional data analysis beyond the 90-day period, additional funds, termed Viking Extension, have been proposed in NASA's planning effort. The Board endorses the Viking Extension, at cost levels shown in Table 1, as a means of exploiting success in the mission.

The Viking approach is appropriate at the present state; however, instrumentation transported to Mars can never equal that available in a terrestrial laboratory, particularly for the life sciences. The Space Science Board is of the opinion that the long-term objectives of exobiology and surface-chemistry investigation are best served by the return of an unsterilized surface sample to earth. Available information points to the possibility that a verifiable system for isolation of the sample from the terrestrial environment can be developed at reasonable cost.

We, therefore, *recommend* that Mars surface-sample return (MSSR) be adopted as a long-term goal and that an early start be made on research and development into a verifiable system of sample isolation.

Interesting results from Viking 1976 can be fully used in the design of MSSR. There should not, however, be a gap in scientific investigations between these two large missions. Many fundamental and preparatory investigations can be made with existing Pioneer and Mariner spacecraft, and a cost-effective medium-range program can be based on them.

We *recommend* that a Mariner polar orbiter mission and Pioneer survivable hard lander and probe mission be undertaken in the period 1978 through 1983.

The Space Science Board has been urged by its Committee on Planetary and Lunar Exploration to recommend that the option of a Viking 1981, based on modifying an existing spacecraft, be kept open until the Viking 1976 results are in. In itself this seems a prudent course of action; however, it is our impression that major costs may be involved, which might eliminate or seriously delay other proposed missions in this period. Given the strategy described in the above recommendations, we see no missions in the recommended mission model (Table 1) that should be displaced to meet such option costs.

IX. EXPLORATION OF THE OUTER SOLAR SYSTEM

The Space Science Board has reached the conclusion that fiscal constraints do not permit the early start of two large programs (Pioneer Jupiter Orbiter and Mariner Jupiter Uranus) for exploration of the outer solar system and believes that the strategy for outer-planets exploration needs to be reassessed.

We, therefore, *recommend* that NASA undertake an immediate re-examination of the strategy for exploration of the outer solar system during the next decade.

We further request the SSB Committee on Planetary and Lunar Exploration to *recommend* to the Board for its 1975 revision of this study a program consistent with the anticipated fiscal constraints.

4
Rationale for Assignment of Priorities

How does a group of disparate—if cooperating—specialists arrive at a judgment of relative priorities in scientific experiments? Their decisions involve the comparison not merely of substances as unlike as chalk and cheese but of topics much more distinct, say, photons and planets. We should like to set down some of our criteria, not explicitly as in any organizing document but as they in fact arose in discussion itself. This requires some analysis of the implications of our work; it seems therefore helpful not merely to extract the principles from discussion but also to cite an example or two, so that the reader may assess the fairness of the conclusion.

I. BALANCE AND CONTINUITY

The phrase "balance and continuity" may adequately describe the most used of all criteria. It serves to remind us that science is not a human activity without parallel, for in most human plans such a criterion must be employed. Momentum is a real property of social as well as physical systems. Plainly, this speaks to the danger of self-serving, but just as plainly it is inevitable that these considerations must play a role in any practical planning. For science, even in its search for novelty, is an ongoing enterprise. Results will never appear unless there are skilled and devoted people, adequate instruments, problems set by previous knowledge, and whole disciplines of study that are based on past results. It is no use to propose experiments if no one is interested in carrying them out or if no one is competent to make the measurements or use the results. The body of existing disciplines must play a role in plans for the future. Thus, the

This chapter was written by SSB member Philip Morrison.

Solar Maximum Mission or the x-ray telescope gain a place in our plans because there are powerful groups of experimenters who can use and will use well such opportunities and who cannot work without them. A gap of many years in such a series of experiments would waste a resource even more precious than the NASA budget. So much we share with every group that plans for the future of persons and organizations.

At the same time, exactly because of this strong parallel, we cannot find in this argument alone any justification for the future of any mission. If no problem exists or no means for solution is present or no novelty seems within reach, mere continuity would not serve for justification. Thus in the cases cited above, we were convinced that the mechanism of solar flares or of x-ray emission in the clusters of galaxies were real problems, open to likely progress by the missions chosen. For example, only one moon mission is on our list, even though in the past a large scientific community has engaged in the study of the moon.

II. THE BATTLE AGAINST NATURE

The work of science is less a marketplace of competing advocates and purveyors than it is a battlefield, with nature as the tireless, fair, but sometime capricious adversary. It is natural to use metaphors of military origin (although we are happy in the realization that victory and defeat in science, while perhaps not bloodless, are not destructive). In this vein, then, we can outline a number of considerations that play a large part in the decisions we make. They relate first to the exploitation of gains.

1. Salients. Sometimes the state of knowledge and power has made a recent advance to form a salient in the front of our ignorance (here the more general form of the cliche is *breakthrough*). It is then clear that such a field will repay more attention; the objectives are known, the means in hand, and we go on to a deeper picture. X-ray astronomy of compact sources, say, is such an area. Thus, the HEAO experiments build upon the proved results of *Uhuru* and give a high priority to x-ray studies designed for faster time resolution and repeated passage across sources.

2. Additions to the Arsenal. Here we have not new results but new weapons for science—instruments or techniques that promise light. Indeed, space science itself is such a case overall. We

might give as examples the cryogenic infrared telescope, opening a new wide channel in astronomy in which we have only slight knowledge of what we might see but the conviction that we can see well in a new channel. Here we may well try to use the instrument first in an economical context, say balloons, as an initial step in its exploitation. A much grander example is LST, for an optical telescope, free of the atmospheric blurring of every previous large telescope, is a new way of seeing. We can outline numerous problems that it should be able to advance.

3. New Intelligence. Sometimes a finding gives us a mere glimpse at some quite new and unexpected problem. It is not that we have made some clear progress but rather that we have opened some new door into a room, still dark, but inviting. Take the active magnetosphere of Jupiter, with its tantalizing suggestion of pulsarlike behavior. It is clear that we want to know more. Or take the brief and little known gamma-ray bursts. A satellite to accumulate more data about these events is a direct extension of the limited intelligence that we have about this surprising feature of the stars (if stars they are).

4. Consolidation of Newly Occupied Territory. The goal of science, following the stages of discovery and exploration, is to achieve a quantitative understanding of the physical processes governing the system under attack. Whereas much of the astronomical and planetary programs recommended in this report involves discovery and exploration, space physics, notably the physics of the earth's outer environment, is in a state where quantitative understanding is within our reach.

III. GENERALITY OF INTEREST

Sometimes we cannot say what is to be found. This is partly true in almost every case. But with the Uranus missions, for example, it is all too true. We could see a strange magnetospheric shock front when the solar wind hits the pole—if in fact the planet has an appreciable magnetic moment. LST, on the other hand, will answer all sorts of questions, over many wavebands and for many types of objects, from planets to forming galaxies. Here we use a criterion of generality; faced with ignorance, hoping for answers we do not have at hand, how many fields, how large a domain of knowledge will the results apply to? In a way this criterion is at war with the ones in the

previous section. We invoke it when we are sure of the measurements but less sure of the objects of investigation. Here the idea is not the exploitation of gains but the width of interest and applicability—within science—of what the instruments might see.

IV. RIPENESS

Ripeness is not all, but it is something. A mission must be based in general on expectations, on previous knowledge (or lack of it). When the mission clearly would undergo a considerable change in plan or importance were a prior and easier to obtain result already at hand, it seems prudent to defer it until it is ripe. This argument might be used—not decisively—against the infrared survey satellite, on the grounds that much more might be learned about the channel from aircraft and balloon flights before the design of an effective orbital spacecraft could be carried out.

V. EXTRASCIENTIFIC CONSEQUENCE OF SCIENCE

Even for the SSB, science cannot be taken to exist outside of the wider context. Applications of science to direct practical concerns, and the impact of scientific results on such deep human interests as the origins and ends of the solar system and the universe, which are clearly not practical at all but philosophical, cannot be neglected. They do not always loom large in our discussions, for other agencies hold final responsibility, and our charge is with science itself. Nevertheless, it is clear to us, and it received much mention, that the sun is our star (or rather the earth is its planet) and solar changes mean more to us than similar phenomena on another star. This adds a long-term but intensely practical interest to all solar missions; will we foresee an ice age if we know the solar-terrestrial interaction in all its detail? Or take Viking. The chance of life on Mars is perhaps not so very great. But the impact on the minds of all human beings, not merely on biologists, of the demonstration of such life is too evident and too important to neglect. This has in fact fueled much of the strong push toward the Viking 1976 landings on Mars.

One more example: images. The well-defined numerical result of measurement is easier for the scientist to wax enthusiastic about than for the outsider. But imagery with its wealth of information, in that very form to which human eye and mind have evolved, makes a real

impact on anyone. The pictures of the vulnerable earth from orbit are justly famous; an albedo measurement would never take their place. Even the scientist, who must recognize a wide exploration as part of his growing knowledge as surely as a good number in one instrumental channel, gains from images. But even if his narrow case were clear against the image, there would be a loss in always choosing the more austere alternative. Generalizing, this idea leads sometimes to the choice of chancy missions, where we know only that we do not know. Not exactly parallel, the out-of-the-ecliptic studies are of a similar kind. They must, in the end, be done, lest we grow narrow. True, they suffer often—and they did here—by deferment under severe constraints of cost.

This provides no full account of our work; it is hard to tease every thread of rationale out of these complex discussions, but it is a beginning picture. Clearly, against these broad ideas we try to argue away all the obvious conflicts of interest and concern that we feel, not generally of any narrow self-serving, fiscal, or even corporate nature but in a wider intellectual field. It is a source of satisfaction that in our discussions we gain wide consensus, and that, as individuals, we have an appreciation of disciplines other than our own. Cosmologists will respond to Jupiter probes, and radio astronomers to the study of gases on Mars. Here resides the strength of the agreement that we finally reach.

51-423 O - 75 - 7

Mr. TALCOTT. I would like to have your comments on it, Dr. Fletcher.

Dr. FLETCHER. We can supply comments for the record. I think it is a very comprehensive report explaining the entire space science and astronomy program and appropriate priorities in terms of the various possibilities. That much I can say before we supply the comprehensive reaction for the record.

Mr. TALCOTT I don't think it would be fair to you to ask for your comment, now, but I think it would be important for us to have something in the record on this.

[The information follows:]

We have the Space Science Board (SSB) report, "Opportunities and Choices in Space Science 1974," under continuing review. The report affirms the high science value of the ongoing program including the High Energy Astronomy Observatories, the Pioneer Venus and Mariner Jupiter/Saturn. The Board endorsed our plans to continue Viking operations on Mars after the nominal 90-day mission if good science data is still being obtained.

We are in accord with a principal recommendation of that report, that the Large Space Telescope (LST) merits a very high priority. The Board recommended a 1976 new start. Because we are still conducting our phase B studies, we were not in a position to consider it for 1976, but do consider it as one of our high priority 1977 candidate new start programs.

We also agree that there are very appealing initiatives in lunar and planetary mission opportunities, as well as other physics and astronomy missions; however, we must judge these not only on their relative scientific merit, but also in the framework of the budget constraints we now face. Thus, it is unlikely that we can accommodate their recommendation of seven 1977 new starts. The discussion of the science rationale and priorities will, however, be of great help in our deliberations as we formulate our future programs.

RESEARCH AND DEVELOPMENT

Mr. BOLAND. We will turn to research and development. Place pages AS–1 through RD 12–3 in the record at this point.

[The material follows:]

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1976 ESTIMATES

GENERAL STATEMENT

The National Aeronautics and Space Administration, established October 1, 1958, conducts space and aeronautical activities for peaceful purposes for the benefit of all mankind. In maintaining United States leadership in research, technology, and utilization in these fields, NASA's program:

--extend our knowledge of the Earth, its environment, the solar system, and the universe;

--expand 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.

The industrial community, under contracts with NASA, will continue to carry forward the prime design, development, and fabrication effort of the major hardware elements involved in the NASA programs. Other elements of the programs will be pursued within NASA installations, other government agencies, universities, and research contractors.

Appropriations totaling $3,539,000,000 are requested for FY 1976 and $958,900,000 for the transition period to support the program described in these justifications.

BUDGET PLAN SUMMARY

(Thousands of Dollars)

	FY 1974	FY 1975	FY 1976	Transition Period
Obligational Authority				
Research and development...	$2,310,882	$2,323,315	$2,678,390	$730,600
Construction of facilities.	101,100	142,655	84,620	14,500
Research and program management.....	743,968	765,175	776,000	213,800
TOTAL, BUDGET PLAN.....	$3,155,950	$3,231,145	$3,539,000	$958,900
TOTAL, OUTLAYS.....	$3,256,216	$3,207,200	$3,498,000	$905,200

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET SUMMARY
(Thousands of Dollars)

Research and Development	Budget Plan FY 1974	FY 1975	FY 1976	Transition Period
MANNED SPACE FLIGHT	999,900	1,110,300	1,414,600	376,600
Space shuttle	475,000	797,500	1,206,000	321,000
Space flight operations	523,400	311,300	207,100	55,100
Advanced missions	1,500	1,500	1,500	500
SPACE SCIENCE	664,482	542,815	582,600	160,300
Physics and astronomy	94,000	136,315	155,800	46,600
Lunar and planetary exploration	392,482	266,000	259,900	73,300
Launch vehicle procurement	178,000	140,500	166,900	40,400
APPLICATIONS	159,000	174,500	175,030	54,700
Space applications	159,000	174,500	175,030	54,700
AERONAUTICS AND SPACE TECHNOLOGY	234,307	237,765	250,250	69,100
Aeronautical research and technology	168,000	166,400	175,350	46,800
Space and nuclear research and technology	66,307	71,365	74,900	22,300
ENERGY PROGRAMS	4,693	4,435	5,900	1,500
Energy technology applications	4,693	4,435	5,900	1,500
TRACKING AND DATA ACQUISITION	244,000	248,000	243,000	66,400
TECHNOLOGY UTILIZATION	4,500	5,500	7,000	2,000
TOTAL RESEARCH AND DEVELOPMENT	2,310,882	2,323,315	2,678,380	730,600
Construction of Facilities	101,100	142,655	84,620	14,500
Research and Program Management	743,968	765,175	776,000	213,800
TOTAL	3,155,950	3,231,145	3,539,000	958,900
TOTAL OUTLAYS	3,256,216	3,207,200	3,498,000	905,200

National Aeronautics and Space Administration

MANNED SPACE FLIGHT

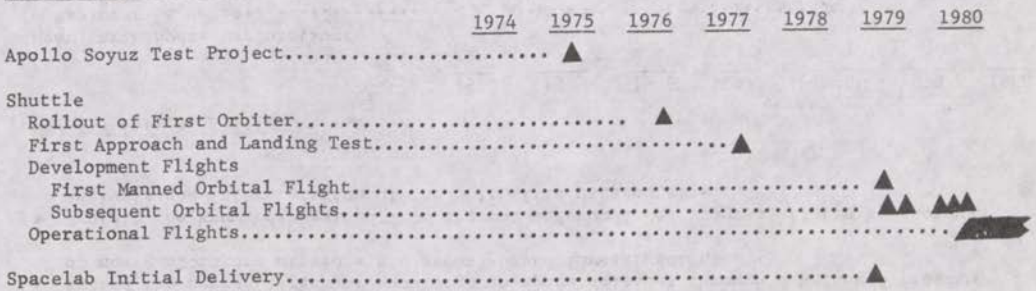
- Promote international cooperation in space

  --Apollo/Soyuz Docking Mission with USSR
  --Spacelab Development by European Space Research Organization

- Develop Space Shuttle Transportation System

  --Routine Access to and from Space
  --Economical Transportation Costs
  --Economical Payload Costs

MAJOR FLIGHT ACTIVITY



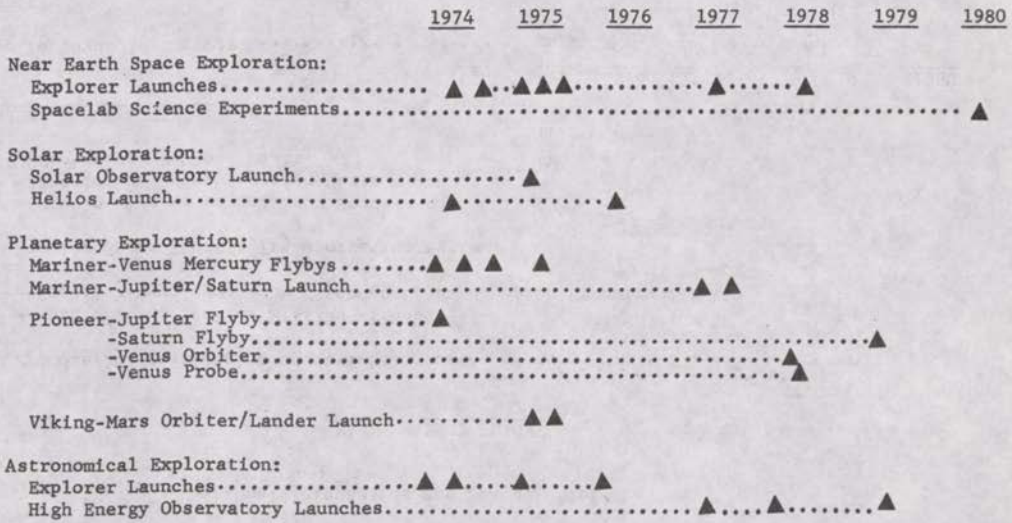
AS 3

National Aeronautics and Space Administration

SPACE SCIENCE

- Extend the current state of knowledge in space sciences through a balanced program of new exploratory 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

MAJOR FLIGHT ACTIVITY

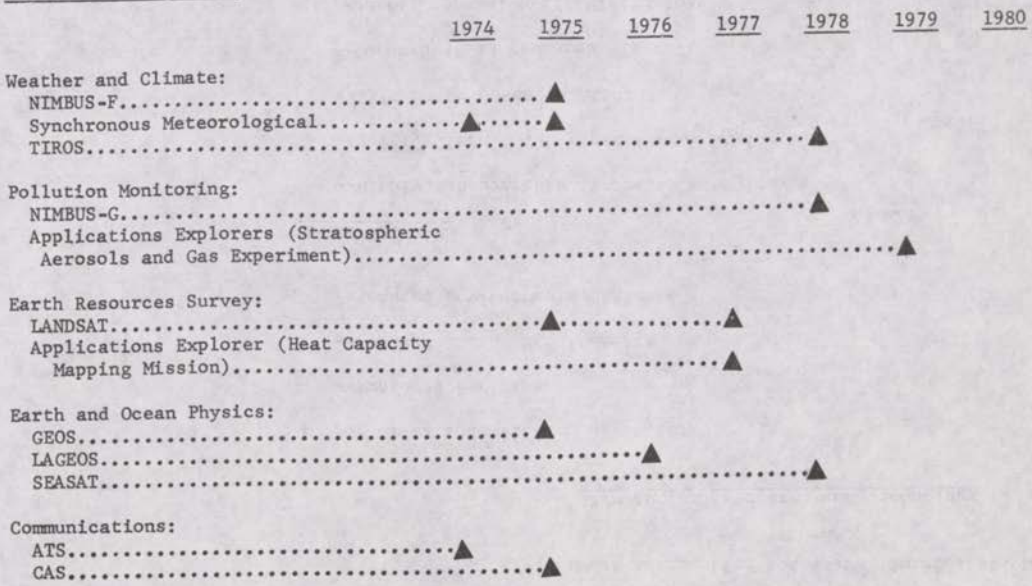


National Aeronautics and Space Administration

SPACE APPLICATIONS

- Develop and demonstrate practical uses of space and space technology.

MAJOR FLIGHT ACTIVITY



National Aeronautics and Space Administration

Aeronautical Research and Technology

- For civil and military aircraft:

  --Improved Performance

  --Reduced Energy Requirements

  --Reduced Environmental Effects

MAJOR PROGRAMS

--Highly Maneuverable Aircraft Technology

--Quiet, Clean, STOL Experimental Engine

--Tilt Rotor Research Aircraft

--Rotor Systems Research Aircraft

--Quiet Propulsive Lift Technology

National Aeronautics and Space Administration

SPACE AND NUCLEAR RESEARCH AND TECHNOLOGY

- Provide a technology base for future space activities
  - --Advanced Spacecraft and Spacecraft Systems Materials and Structures
  - --Improved Chemical and Electric Propulsion
  - --High-Reliability Electronics
  - --Improved Thermal Design for Spacecraft
  - --Efficient Nuclear and Non-Nuclear Power Systems

National Aeronautics and Space Administration

ENERGY TECHNOLOGY APPLICATIONS

- To assist in insuring the attainment (and maintenance) of National energy self-sufficiency

  --Provides support to federal, state and local governmental agencies in implementing energy programs which requires or can benefit from NASA's aerospace systems technology and management techniques.

  --Evaluates the potential of various elements of aerospace technology for energy

National Aeronautics and Space Administration

TRACKING AND DATA ACQUISITION

- Worldwide networks of ground stations, an instrumentation ship, and instrumented aircraft interconnected with highly reliable communications to provide support to:

  --Manned Missions - Apollo/Soyuz Test Project

  --Automated Earth Orbiting Missions - Covers approximately 40 Active Satellites including upcoming Synchronous Meteorological Satellite (SMS)B, NIMBUS F, Geodynamic Experimental Ocean Satellite (GEOS)C, Earth Resources Technology Satellite (LANDSAT)2 and Orbiting Solar Observatory (OSO)I missions

  --Planetary Missions - In addition to continuing Pioneer, Helios I, and Mariner support, Viking 75 A&B and Helios B missions will be covered

  --Sounding Rockets

  --Research Aircraft

TECHNOLOGY UTILIZATION

- Accelerate the dissemination of scientific and technical information generated by the conduct of the space and aeronautics programs.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1976 ESTIMATES

SUMMARY OF APPROPRIATIONS
(Thousands of Dollars)

Appropriations	1974 PL 93-137*	1975 PL 93-414*	1976 Request	Transition Period Request
Research and Development	$2,194,000	$2,331,015	$2,678,380	$730,600
Basic Appropriation	2,194,000	2,326,580	2,678,380	730,600
Special Energy Research and Development Appropriation Act, 1975 (PL 93-322)	---	4,435	---	---
Construction of Facilities	101,100	140,155	84,620	14,500
Research and Program Management	744,600	759,975	776,000	213,800
Basic Appropriation	(707,000)	(740,000)	(776,000)	(213,800)
Supplemental Appropriation for civilian pay raises (PL 93-305)	(37,600)	---	---	---
Proposed supplemental for civilian pay raises	---	(19,975)	---	---
Total	$3,039,700	$3,231,145	$3,539,000	$958,900

* Except as noted

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1976 ESTIMATES

SUMMARY RECONCILIATION OF APPROPRIATIONS TO BUDGET PLANS
(Thousands of Dollars)

Fiscal Year 1974	Total	Research and Development	Construction of Facilities	Research and Program Management
Basic Appropriation, PL 93-137	$3,002,100	$2,194,000	$101,100	$707,000
Supplemental Appropriation PL 93-305	37,600	---	---	37,600
Total Appropriation (Budget Authority).	3,039,700	2,194,000	101,100	744,600
1973 & prior funds applied to 1974 program plan	+116,882	+116,882	---	---
Unobligated balance lapsing	-632	---	---	-632
Total Budget Plan	$3,155,950	$2,310,882	$101,100	$743,968
Fiscal Year 1975				
Appropriation: PL 93-414	$3,206,735	$2,326,580	$140,155	$740,000
*PL 93-322	4,435	4,435	---	---
Subtotal	3,211,170	2,331,015	140,155	740,000
Proposed supplemental for civilian pay raises	19,975	---	---	19,975
Transfers between appropriations	---	-7,700	+2,500	+5,200
Total Adjusted Appropriation (Budget Authority)/Budget Plan	$3,231,145	$2,323,315	$142,655	$765,175

* Special Energy Research and Development Appropriation Act, 1975.

AS 11

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1976 ESTIMATES

SUMMARY RECONCILIATION OF APPROPRIATIONS TO BUDGET PLANS (CONTINUED)
(Thousands of Dollars)

Fiscal Year 1976	Total	Research and Development	Construction of Facilities	Research and Program Management
Appropriation request/Budget Plan.....	$3,539,000	$2,678,380	$84,620	$776,000
Transition Period				
Appropriation request/Budget Plan.....	$958,900	$730,600	$14,500	$213,800

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1976 AND TRANSITION PERIOD ESTIMATES

SUMMARY OF APPROPRIATION BUDGET PLANS BY INSTALLATION

(In millions of dollars)

Installation	Research and Development				Construction of Facilities				Research and Program Management				Total			
	1974	1975	1976	Transition Period	1974	1975	1976	Transition Period	1974	1975	1976	Transition Period	1974	1975	1976	Transition Period
Johnson Space Center	614.1	797.9	1014.5	267.5	11.1	3.1	7.2	.5	118.0	121.6	125.2	29.8	743.2	922.6	1146.9	297.8
John F. Kennedy Space Center, NASA	110.9	113.8	106.6	34.5	18.9	66.2	37.0	.7	93.6	95.9	95.0	35.0	223.4	275.9	238.6	70.2
Marshall Space Flight Center	297.6	285.8	409.3	105.7	18.6	11.6	1.4	1.1	136.6	131.3	130.5	34.4	452.8	428.7	541.2	141.2
National Space Technology Laboratories	1.5	8.2	9.1	2.4	11.8	.1	.1	.2	1.6	1.7	1.7	.4	14.9	10.0	10.9	3.0
Goddard Space Flight Center	403.0	385.2	354.0	104.1	2.5	3.7	1.3	1.4	97.5	104.8	105.8	27.7	503.0	493.7	461.1	133.2
Wallops Flight Center	14.2	16.3	17.6	4.2	3.1	3.5	1.0	.2	11.5	12.1	12.7	3.5	28.8	31.9	31.3	7.9
Jet Propulsion Laboratory	127.1	169.8	186.2	55.1	2.0	11.1	1.9	1.6	--	--	--	--	129.1	180.9	188.1	56.7
Ames Research Center	85.3	114.5	138.9	37.8	2.1	5.3	4.8	1.3	46.4	48.4	49.3	12.8	133.8	168.2	193.0	51.9
Flight Research Center	15.6	16.3	20.8	5.2	.3	5.1	5.8	--	12.2	13.2	13.7	4.9	28.1	34.6	40.3	10.1
Langley Research Center	355.9	192.0	154.5	45.9	7.2	5.4	4.2	1.3	83.8	88.1	90.7	23.4	446.9	285.5	249.4	70.6
Lewis Research Center	185.6	132.6	170.0	43.5	2.2	5.6	1.4	.8	79.8	79.9	81.9	21.9	267.6	218.1	253.3	66.2
NASA Headquarters	100.1	90.9	96.9	24.7	--	--	--	--	63.0	68.2	69.5	20.0	163.1	159.1	166.4	44.7
Construction of Facilities Programs																
Various Locations					4.0	7.5	--	--					4.0	7.5	--	--
Facility Planning and Design					13.6	10.9	9.3	2.8					13.6	10.9	9.3	2.8
Balance of the following programs undistributed by installation																
Space Shuttle Facilities					--	--	3.0	--					--	--	3.0	--
Rehabilitation and Modification					1.9	1.6	3.8	1.8					1.9	1.6	3.8	1.8
Minor Construction					1.8	2.0	2.4	.8					1.8	2.0	2.4	.8
Total Budget Plan	2310.9	2323.3	2678.4	730.6	101.1	142.7	84.6	14.5	744.0	765.2	776.0	213.8	3136.0	3231.2	3539.0	958.9

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

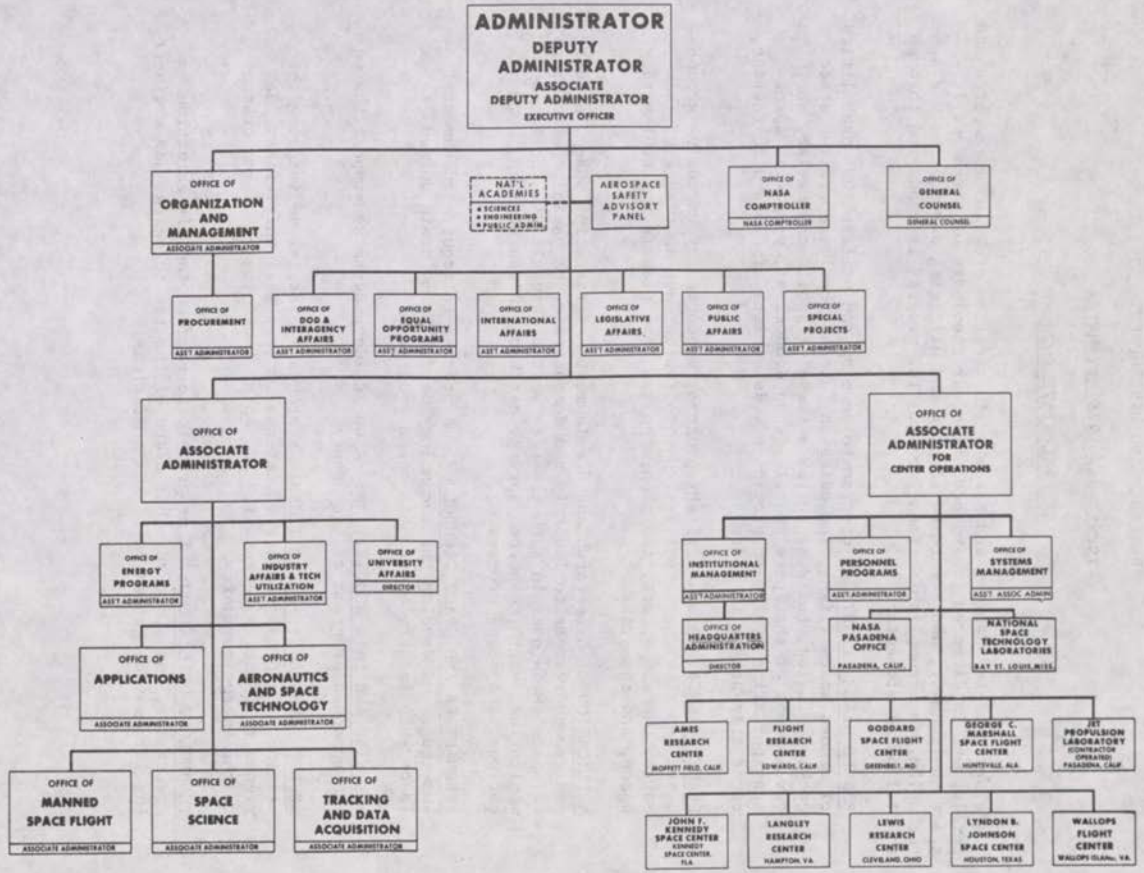
RESEARCH AND PROGRAM MANAGEMENT

TOTAL NUMBER OF PERMANENT POSITIONS

END OF YEAR

INSTALLATION	FY 1974	FY 1975	FY 1976
John F. Kennedy Space Center, NASA.....	2,309	2,259	2,259
Johnson Space Center.....	3,652	3,613	3,613
Marshall Space Flight Center.....	4,500	4,113	4,113
National Space Technology Laboratories.....	65	70	70
Goddard Space Flight Center.....	3,808	3,751	3,751
Wallops Flight Center.....	420	415	415
Ames Research Center.....	1,701	1,679	1,679
Flight Research Center.....	484	489	489
Langley Research Center.....	3,375	3,332	3,332
Lewis Research Center.....	3,115	3,025	3,025
NASA Headquarters.....	1,591	1,570	1,570
TOTAL.....	25,020	24,316	24,316

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



AS 15

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

GENERAL STATEMENT

The National Aeronautics and Space Administration program of research and development is directed toward advancing our knowledge of earth and its space environment, and toward developing and utilizing aeronautics and space technology to accomplish National goals. The program is conducted through the following elements:

MANNED SPACE FLIGHT: A program to develop and utilize the capabilities of manned space flight, including an international cooperative space docking mission, building on the success of Apollo and Skylab, and development of the Space Shuttle as an economical, versatile space transportation system to provide a wide variety of users with routine, round trip access to space.

SPACE SCIENCE: A space flight program, supported by extensive ground-based and airborne investigations, to further our knowledge of the earth, the atmosphere, the moon, the sun, the planets, interplanetary space, and the stars.

APPLICATIONS: A research and development program using space, aircraft, and ground systems to identify and demonstrate the useful applications of space techniques in such areas as weather and climate, pollution monitoring, earth resources survey, earth and ocean physics, communications, and space processing.

AERONAUTICS AND SPACE TECHNOLOGY: A program to acquire fundamental knowledge and develop the technology needed to maintain United States leadership in aeronautics and space programs.

TRACKING AND DATA ACQUISITION: A worldwide program to support the manned and unmanned programs of the agency.

ENERGY TECHNOLOGY APPLICATIONS: A program to assist in insuring the attainment and maintenance of national energy self-sufficiency, designed to identify aeronautics and space technologies of importance to the energy community.

TECHNOLOGY UTILZATION: A program to accelerate the dissemination to government, industry and other users of the technological and engineering information gained during NASA missions.

MANNED SPACE FLIGHT

The final preparations are now in progress for the launch of the Apollo Soyuz Test Project (ASTP), the first international cooperative manned flight. During FY 1976, the ASTP flight will occur and activities on the development of the Space Shuttle and the NASA support to the European development of the Spacelab will continue to intensify as we move forward to a new era in expanding the beneficial returns from space operations.

The Apollo Soyuz Test Project, a joint US/USSR effort to develop and test systems for rendezvous and docking of manned spacecraft, is planned for launch in July 1975. During this mission, United States astronauts using a modified Apollo Command and Service Module and a newly developed Docking Module will rendezvous and dock in earth orbit with a Soyuz spacecraft manned by Soviet cosmonauts. During the mission, joint activities will be conducted by the two crews, including crew transfers between the two spacecraft.

The Space Shuttle is the key element of an economical versatile space transportation system for routine access to and from low earth orbit. The Shuttle will consist of a reusable delta-wing orbiter vehicle with three main engines, a large expendable propellant tank, and reusable twin solid rocket boosters. The Shuttle will provide for placement and retrieval of satellites, in-orbit servicing of satellites, short-duration manned orbital missions, and delivery to earth orbit of payloads and propulsive stages for high energy and escape missions. The advent of routine, rapid transportation to and from low earth orbit for both unmanned payloads and for scientists and other personnel without special flight training, will revolutionize our concepts of using space. In addition to the savings resulting from reduced transportation costs, major savings are anticipated in payload costs, resulting from repair and reuse of payloads and from relaxation of the stringent payload weight, size, and reliability requirements currently imposed.

All the main elements of the Space Shuttle are now under contract and the design and component fabrication and testing activities are progressing well toward the first approach and landing test in 1977 and the first manned orbital flight of the Space Shuttle in 1979.

The Spacelab will be a multipurpose payload carrier to be used in conjunction with the Space Shuttle. The Spacelab will allow researchers and scientists to conduct their experiments personally in a space environment. It is being designed and built for NASA by the European Space Research Organization (ESRO), with ten European nations participating in the Spacelab development.

SPACE SCIENCE

The Space Science program is a broad-based program of scientific exploration using data from manned and automated spacecraft, sounding rockets, balloons,

aircraft, and ground-based research. Investigations are directed toward observing and understanding the characteristics and interactions of the earth and its atmosphere, the moon, the sun, the planets, the stars, and interplanetary and interstellar space.

The Skylab program provided a wealth of new information about the sun, complementing and adding to data received from the series of automated Orbiting Solar Observatories. These solar observations will be continued through the quiescent period of the solar cycle using another Orbiting Solar Observatory, OSO-I, to be launched in 1975. Project definition and advanced technology development is continuing for the Solar Maximum mission, which would gather data during the next period of peak solar activity. The Orbiting Astronomical Observatory-3, Copernicus, continues to transmit data on the stars and the interstellar matter. The High Energy Astronomy Observatory program is moving forward with the development of flight hardware for launch in 1977, 1978, and 1979, to explore the high energy universe in the x-ray, gamma ray and cosmic ray spectrum. Planning and technological activity is underway on concepts for a Large Space Telescope, a facility which could provide a revolutionary capability in the 1980's for studies of our universe by the international scientific community.

Analysis continues on the data returned by the Apollo missions and on that being received from the Apollo Lunar Surface Experiment Packages left on the lunar surface by the astronauts, as well as the data returned from current and previous planetary missions. Pioneers 10 and 11 completed their flybys of Jupiter, returning close-up imagery and demonstrating the ability of spacecraft to survive the hazards of both the asteroid belt and Jupiter's intense radiation. Pioneer 11 is proceeding on toward the first encounter of Saturn in 1979. Meanwhile, Mariner 10 is proceeding toward a third encounter of Mercury, following two successful visits to that innermost planet last year, and an earlier swing-by of Venus which provided a demonstration of the first gravity-assisted maneuver to go from one planet to another. International cooperative missions to explore the interplanetary region near the sun are underway by the United States and West Germany. These missions are Helios 1, launched in December, 1974, and Helios B, to be launched in 1976. Two Viking missions, each of which will contain both an Orbiter and a Lander, will be launched in 1975 with a planned Mars landing in July 1976. The primary purpose of these missions is to search for the existence of life or the possibility of past or future life on Mars. In 1977, two Mariner spacecraft will be launched to fly by Jupiter and, utilizing a gravity assist from that planet, will travel on to investigate Saturn. In 1978, two Pioneer spacecraft will be launched, one to orbit Venus and another to probe its dense atmosphere. These spacecraft will return a wealth of data on Venus and help to answer questions about earth's atmosphere and dynamics.

The Space Science program also provides launch vehicles for the science and applications missions of the agency, as well as providing launches on a reimbursable basis to other government users and a growing number of international and domestic commercial customers.

APPLICATIONS

Demonstrations of the use of space and space-related technology for practical benefits are the primary objective of the Applications program. Specific areas of such demonstrations include weather and climate, pollution monitoring, earth resources survey, earth and ocean physics, space processing, and communication.

Work continues on development of an ocean dynamics satellite, SEASAT A, to demonstrate a wide range of physical ocean phenomena, including sea state, the location and motion of currents, global circulation patterns, ocean tides, wind stress and geoid udulations. This satellite, scheduled for launch in 1978, should provide global information on the dynamics of the interactions of the air and the sea, which is important to understanding global weather and climate patterns.

The second Earth Resources Technology Satellite, Landsat B, was launched in January 1975 to continue the space-based earth resources survey begun so successfully by Landsat 1. The third satellite in the series, Landsat C, will fly in 1977 with improved instrumentation, to provide the continuity of data analysis effort necessary to long-range user community requirements. Additionally, the practical capability of Landsat information systems to make substantial contributions in the most promising areas of research is being documented through the concerted effort of user agencies and resources managers.

Understanding of earthquake mechanisms will be enhanced by both ground-based experiments and development work on LAGEOS, a high density, laser reflector satellite. The LAGEOS, when launched in 1976, will provide a stable, long term reference point for earth crustal motion studies.

Communications satellites include an experimental Applications Technology Satellite (ATS-6), launched in 1974: to begin a national and international experimental communications program in satellite broadcasting; and a joint US/Canadian project--Cooperative Applications Satellite (CAS-C), scheduled for launch in 1975.

Among other missions under development in the Applications program are TIROS-N, to be flown in 1978 as the prototype for a third generation operational weather satellite system, and Nimbus-G, a 1978 experimental satellite to demonstrate the use of a space platform to monitor air pollution and to measure ocean dynamics. Two applications Explorer projects are also included: a heat capacity mapping mission in 1977 to locate and map geothermal sources in the earth's crust and to identify materials contained in surface rocks; and a single-instrument satellite mission to be launched in 1979 to detect and map stratospheric aerosols and gas concentrations.

Effort will continue in data management to improve the definition and integration of ground and spacecraft data. Systems analyses and cost/benefit studies will be pursued to test the effectiveness of space applications.

AERONAUTICS AND SPACE TECHNOLOGY

The Aeronautics program will continue to advance aeronautical technology to make possible safer, more economical and environmentally acceptable air transportation systems which are responsive to current and future national needs. This technology will help to maintain the strong competitive position of the United States in the international aviation market place and support the military in maintaining the superiority of the Nation's military aircraft.

The program contains a strong fundamental research effort in the disciplinary areas of materials, structures, avionics, propulsion, aerodynamics and man-vehicle interactions to provide advanced technology to meet the future needs of civil aviation. The program will focus on reducing aircraft energy consumption and the undesirable environmental effects of noise and pollution by providing the technology for quiet, clean and efficient propulsion systems; the reduction of aerodynamic drag; the reduction of aircraft structural weight through the application of active control concepts, advanced materials, and structural concepts; and by the characterization of candidate nonpetroleum-based fuels for aircraft. Improvement of terminal area operations and safety will be pursued through the development of technology in areas such as avionics systems, operating procedures, crashworthy aircraft structures and fire-resistant aircraft interior materials.

The technology for advanced long haul and short haul air transportation systems will be advanced by a focused technology effort in the areas of Short Takeoff and Landing (STOL) systems, Vertical Takeoff and Landing (VTOL) systems, rotorcraft systems, Conventional Takeoff and Landing (CTOL) subsonic systems, and a modest effort aimed at developing supersonic and hypersonic technology to provide options for aircraft of the future.

The Space and Nuclear program will continue to advance technology to provide a technology base that will adequately support current and future space activities involved in the exploration and exploitation of space, and provide standardized, low cost components and systems for the future. Much of the basic technology developed in the program is applicable to a broad range of terrestrial problems in fields such as energy and communications.

The program will advance technology in the areas of materials and structures for use in spacecraft; chemical and electric propulsion systems to expand mission capabilities; highly reliable and efficient electronic components; guidance, control and information-handling systems; aerothermodynamics of spacecraft entry into planetary atmospheres; and power systems to meet the more stringent requirements of future space missions.

TRACKING AND DATA ACQUISITION

This program provides for continuation of tracking and data acquisition support for manned and unmanned earth orbiting spacecraft, planetary missions, sounding rockets, and research aircraft. This support is provided by a worldwide network of NASA ground stations, an instrumentation ship, and instrumented aircraft, 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 also are provided to process into meaningful form the large amounts of scientific, applications, and engineering data which are collected from flight projects.

The support workload will remain high with the Spaceflight Tracking and Data Network (STDN) supporting an average of approximately 40 unmanned scientific and applications spacecraft and the Deep Space Network (DSN) supporting a full complement of planetary missions. Upcoming missions to be supported by STDN include the Synchronous Meteorological Satellite B, Nimbus F, Geodynamic Experimental Ocean Satellite C, the second Earth Resources Technology Satellite, Orbiting Solar Observatory I and the Apollo Soyuz Test Project. Additions to support now provided by DSN will include the two Viking missions and Helios B.

ENERGY PROGRAMS

To assist in insuring the attainment and maintenance of national energy self sufficiency, the Energy Technology Applications Program has been established to provide support to other agencies in advanced research, technology and development; define and, if appropriate, implement programs which require broad application of aerospace technology and management techniques; and provide support of the application of aerospace technology to immediate energy problems.

TECHNOLOGY UTILIZATION

This program provides for wide and rapid dissemination of scientific and technical information acquired as a result of the agency programs. Recipients include other government agencies, the university and nonprofit research community, and industry. Also included is a program to identify public sector problems capable of solution by the application of aerospace technology. These efforts are accomplished through a series of publications and through Industrial Applications Centers.

FUNDING

The FY 1976 Research and Development budget plan totals $2,678,380,000 an increase of $355,065,000 from FY 1975.

Research and Development outlays in FY 1976 are estimated at $2,613,900,000 up $271,000,000 from the $2,342,900,000 estimate for FY 1975.

The Budget Plan and Outlay estimates for the transition period for Research and Development are $730,600,000 and $659,900,000 respectively.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

RESEARCH AND DEVELOPMENT

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 [section 7 of the National Aeronautics and Space Administration Authorization Act, 1975] *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, [$2,326,580,000] ***$2,678,580,000***, to remain available until expended.

[For necessary expenses of the National Aeronautics and Space Administration relating to programs and other activities in research and development, including services as authorized by 5 U.S.C. 3109, $4,435,000, to remain available until expended.]

For "Research and development," to be available July 1, 1976, $730,600,000, to remain available until expended. (42 U.S.C. 2451, et seq.; Department of Housing and Urban Development; Space, Science, Veterans, and Certain Other Independent Agencies Appropriation Act, 1975; Special Energy Research and Develop ment Appropriation Act, 1975; additional authorizing legislation to be proposed for fiscal year 1976, and for the period beginning July 1, 1976.)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Research and Development

Program and Financing (in thousands of dollars)

Identification code 27-00-0108-0-1-999	Budget plan (amounts for research and development actions programed)			Costs and obligations		
	1974 actual	1975 estimate	1976 estimate	1974 actual	1975 estimate	1976 estimate
Program by activities:						
Direct program:						
1. Manned space flight:						
(a) Space shuttle	475,000	797,500	1,206,000	502,116	850,000	1,143,000
(b) Space flight operations	523,400	311,300	207,100	583,751	354,200	238,200
(c) Advanced manned mission studies	1,500	1,500	1,500	1,966	2,300	1,800
(d) Apollo	----------	----------	----------	4,097	3,500	----------
2. Scientific investigations in space:						
(a) Physics and astronomy	104,300	157,215	182,100	115,683	154,400	181,300
(b) Lunar and planetary exploration	456,282	285,000	300,600	366,374	369,600	302,200
(c) Launch vehicle development and support	89,700	93,000	88,000	89,883	102,172	89,600
3. Space applications	173,200	182,100	186,930	157,792	168,428	194,900
4. Space research and technology	66,307	71,365	74,900	68,717	81,000	73,600
5. Aeronautical research and technology	168,000	166,400	175,350	155,291	172,700	174,500
6. Energy programs	4,693	4,435	5,900	1,756	5,000	5,400
7. Supporting activities:						
(a) Tracking and data acquisition	244,000	248,000	243,000	246,173	257,000	259,500
(b) Sustaining university program	----------	----------	----------	729	700	----------
(c) Technology utilization	4,500	5,500	7,000	4,230	5,700	6,000
Total direct program costs, funded	2,310,882	2,323,315	2,678,380	2,298,558	2,526,700	2,670,000
Reimbursable program:						
1. Manned space flight:						
(a) Space shuttle	----------	----------	----------	60	8	----------
(b) Space flight operations	9,751	12,375	14,878	8,897	14,830	14,878
(d) Apollo	----------	----------	----------	45	425	----------
2. Scientific investigations in space:						
(a) Physics and astronomy	12,187	10,192	5,550	9,086	13,086	5,550
(b) Lunar and planetary exploration	----------	66	----------	----------	66	----------
3. Space applications	181,600	165,814	144,357	130,490	235,557	144,357
4. Space research and technology	433	693	647	437	1,050	647
5. Aeronautical research and technology	23,163	20,888	17,502	19,170	34,527	17,502
6. Energy programs	3,946	10,120	35,100	868	12,496	35,100
7. Supporting activities:						
(a) Tracking and data acquisition	394	525	426	24	622	426
(c) Technology utilization	435	2,027	1,740	277	2,243	1,740
Total reimbursable program costs	231,909	222,700	220,200	169,354	314,890	220,200
Total program costs, funded	2,542,791	2,546,015	2,898,580	2,467,912	2,841,590	2,890,200
Change in selected resources (undelivered orders and stores)	----------	----------	----------	−2,100	34,995	80,380
10 Total	2,542,791	2,546,015	2,898,580	2,465,812	2,876,585	2,970,580

Program and Financing (in thousands of dollars)—**Continued**

Identification code 27-00-0108-0-1-999	Budget plan (amounts for research and development actions programed)			Costs and obligations		
	1974 actual	1975 estimate	1976 estimate	1974 actual	1975 estimate	1976 estimate
Financing:						
Receipts and reimbursements from:						
11 Federal funds	−104,645	−83,830	−110,845	−104,645	−83,830	−110,845
14 Non-Federal sources	−127,264	−138,870	−109,355	−127,264	−138,870	−109,355
21 Unobligated balance available, start of year:						
For completion of prior year budget plans:						
Direct	.....	.....	.....	−279,634	−310,380	−72,000
Reimbursable	.....	.....	.....	−45,978	−92,190	.....
Available to finance new budget plans: Direct	−116,882	.....	.....	−116,882	.....	.....
24 Unobligated balance available, end of year:						
For completion of prior year budget plans:						
Direct	.....	.....	.....	310,380	72,000	.....
Reimbursable	.....	.....	.....	92,190	.....	.....
25 Unobligated balance lapsing	.....	.....	.....	21	.....	.....
Budget authority	2,194,000	2,323,315	2,678,380	2,194,000	2,323,315	2,678,380
Budget authority:						
40 Appropriation	2,194,000	2,331,015	2,678,380	2,194,000	2,331,015	2,678,380
41 Transferred to other accounts	.....	−7,700	.....	.....	−7,700	.....
43 **Appropriation (adjusted)**	2,194,000	2,323,315	2,678,380	2,194,000	2,323,315	2,678,380
Relation of obligations to outlays:						
71 Obligations incurred, net				2,233,903	2,653,885	2,750,380
72 Obligated balance, start of year				959,243	771,594	1,082,579
74 Obligated balance, end of year				−771,594	−1,082,579	−1,219,059
90 Outlays				2,421,552	2,342,900	2,613,900

Note—Reconciliation of budget plan to obligations:	*1974 actual*	*1975 estimate*	*1976 estimate*
Total budget plan	2,542,791	2,546,015	2,898,580
Deduct portion of budget plan to be obligated in subsequent years	301,614	72,000	.....
Add obligations of prior year budget plans	224,635	402,570	72,000
Total obligations	2,465,812	2,876,585	2,970,580

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET SUMMARY
(Thousands of Dollars)

Research and Development	Budget Plan FY 1974	FY 1975	FY 1976	Transition Period
MANNED SPACE FLIGHT	999,900	1,110,300	1,414,600	376,600
Space shuttle	475,000	797,500	1,206,000	321,000
Space flight operations	523,400	311,300	207,100	55,100
Advanced missions	1,500	1,500	1,500	500
SPACE SCIENCE	664,482	542,815	582,600	160,300
Physics and astronomy	94,000	136,315	155,800	46,600
Lunar and planetary exploration	392,482	266,000	259,900	73,300
Launch vehicle procurement	178,000	140,500	166,900	40,400
APPLICATIONS	159,000	174,500	175,030	54,700
Space applications	159,000	174,500	175,030	54,700
AERONAUTICS AND SPACE TECHNOLOGY	234,307	237,765	250,250	69,100
Aeronautical research and technology	168,000	166,400	175,350	46,800
Space and nuclear research and technology	66,307	71,365	74,900	22,300
ENERGY PROGRAMS	4,693	4,435	5,900	1,500
TRACKING AND DATA ACQUISITION	244,000	248,000	243,000	66,400
TECHNOLOGY UTILIZATION	4,500	5,500	7,000	2,000
TOTAL	2,310,882	2,323,315	2,678,380	730,600

National Aeronautics and Space Administration

FY 1975 BUDGET AUTHORITY DEFERRED

The FY 1975 estimates contained in the National Aeronautics and Space Administration FY 1976 Budget Estimates include $72 million of the 1975 Research and Development appropriation identified for deferral into FY 1976 as part of the President's budget restraint message of November 26, 1974. These funds, which are planned for obligation early in FY 1976, are distributed as follows:

Space Flight Operations	20,000,000
Apollo Soyuz Test Project	20,000,000
Physics and Astronomy	3,000,000
Orbiting Astronomical Observatories	300,000
Solar Maximum Mission-Advanced Technological Development	550,000
Airborne Research	200,000
Sounding Rockets	1,050,000
Supporting Research and Technology/Advanced Studies	900,000
Lunar and Planetary Exploration	8,000,000
Pioneer-Venus	5,000,000
Lunar Sample Analysis	1,200,000
Lunar Data Analysis	1,300,000
Lunar Science Supporting Research and Development	500,000
Space Applications	16,000,000
TIROS-N	2,800,000
Global Atmospheric Research Program	500,000
Weather and Climate: Advanced techniques in observing and forecasting	100,000
Nimbus-G	7,200,000
Pollution Monitoring: Sensor definition and feasibility evaluations	200,000
SEASAT-A	500,000
Tectonic Plate Motion	500,000
Earth Resources Survey: Data interpretation techniques, special investigation and data analysis	1,000,000
Earth and Ocean Physics Data Analysis	200,000
Earth and Ocean Physics Measurement Systems, Forecasting Techniques, and Modeling	200,000
Data Management	500,000
Shuttle Payloads Development	900,000
Advanced Applications Flight Experiments	900,000
Heat Capacity Mapping Mission	500,000

FY 1975 Deferral Budget Authority - Continued

Aeronautical Research and Technology	13,500,000
Systems Technology Programs	4,000,000
Quiet, Clean, Short-Haul Experimental Engine	2,000,000
Tilt Rotor Research Aircraft	2,000,000
Quiet Propulsive Lift	5,500,000
Space and Nuclear Research and Technology	1,500,000
Research and Technology Base	1,200,000
Systems Technology Programs	300,000
Tracking and Data Acquisition	10,000,000
Systems Implementation	6,200,000
Supporting Research and Technology	200,000
Tracking and Data Relay Satellite Studies	3,600,000
Total Deferrals	72,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1976 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	Flight Research Center	Langley Research Center	Lewis Research Center	NASA Headquarters
OFFICE OF MANNED SPACE FLIGHT, TOTAL	1974	999,900	586,252	106,731	277,892	1,450	848	645	48	9,907	100	1,172	250	14,605
	1975	1,110,300	753,163	100,875	225,487	8,000	444	500	---	8,065	106	97	200	13,363
	1976	1,414,600	967,298	90,000	327,550	8,900	440	600	---	8,450	75	237	250	10,800
	TP	376,600	254,465	31,250	82,150	2,300	125	200	---	2,525	---	85	200	3,300
Space shuttle	1974	475,000	357,102	2,901	110,311	700	---	---	---	175	---	174	---	3,637
	1975	797,500	622,113	14,000	149,687	1,000	68	---	---	---	---	28	---	10,604
	1976	1,206,000	864,948	50,900	278,400	1,900	100	---	---	---	---	52	---	9,700
	TP	321,000	227,265	21,000	69,200	500	25	---	---	---	---	10	---	3,000
Space Flight operations	1974	521,400	228,574	103,700	167,006	750	848	645	48	9,720	100	998	250	10,761
	1975	311,300	130,600	86,725	75,300	7,000	376	500	---	8,065	106	69	200	2,359
	1976	207,100	101,750	38,950	48,550	7,000	340	600	---	8,450	75	185	250	950
	TP	55,100	27,000	10,200	12,750	1,800	100	200	---	2,525	---	75	200	250
Advanced missions	1974	1,500	576	130	575	---	---	---	---	12	---	---	---	207
	1975	1,500	450	150	500	---	---	---	---	---	---	---	---	400
	1976	1,500	600	150	600	---	---	---	---	---	---	---	---	150
	TP	500	200	50	200	---	---	---	---	---	---	---	---	50
OFFICE OF SPACE SCIENCE, TOTAL	1974	664,482	8,282	3,878	11,207	---	122,137	58,631	2,205	15,701	---	284,663	102,574	55,204
	1975	542,815	11,758	11,670	49,725	---	110,465	91,761	2,469	44,758	---	107,293	68,044	44,872
	1976	582,600	11,884	15,160	71,800	---	92,373	100,147	2,865	72,225	---	61,791	102,168	52,187
	TP	160,300	3,039	3,000	20,650	---	27,315	29,103	825	19,007	---	20,176	24,700	12,485
Physics and astronomy	1974	94,000	180	---	8,927	---	56,755	650	2,150	6,435	---	2,708	---	16,195
	1975	136,315	850	---	49,505	---	55,419	628	2,404	6,927	---	1,358	---	19,224
	1976	155,800	1,000	---	71,400	---	53,038	700	2,800	7,400	---	862	---	18,600
	TP	46,600	200	---	20,550	---	17,075	400	800	1,930	---	925	---	4,700
Lunar and planetary exploration	1974	392,482	8,102	---	25	---	6,380	57,371	55	9,266	---	274,273	---	37,010
	1975	266,000	10,908	22	20	---	8,558	90,937	55	37,831	---	94,476	---	23,193
	1976	259,900	10,884	---	---	---	7,553	99,397	55	64,825	---	48,914	---	28,272
	TP	73,300	2,839	---	---	---	1,640	28,603	25	17,057	---	16,151	---	6,985

Launch vehicle procurement	1974	178,000	---	3,878	2,255	---	59,002	610	---	---	---	7,682	102,574	1,999
	1975	140,500	---	11,648	200	---	46,488	196	10	---	---	11,459	68,044	2,455
	1976	166,900	---	15,160	400	---	31,782	50	10	---	---	12,015	102,168	5,315
	TP	40,400	---	3,000	100	---	8,600	100	---	---	---	3,100	24,700	800
OFFICE OF APPLICATIONS (Space applications)	1974	159,000	18,133	285	4,155	---	100,285	4,757	6,267	6,598	---	8,749	3,935	5,836
	1975	174,500	32,400	1,200	7,100	200	92,200	9,600	7,300	5,700	---	8,900	2,600	7,300
	1976	175,030	33,030	1,300	6,500	200	86,400	14,400	9,300	5,400	---	9,300	2,300	6,700
	TP	54,700	9,500	200	2,050	50	30,100	4,500	1,900	1,600	---	2,700	400	1,700
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, TOTAL	1974	234,307	959	---	3,467	---	4,650	14,257	137	53,139	13,464	60,842	77,784	5,608
	1975	237,765	175	50	2,960	---	5,656	17,093	346	55,746	13,587	75,652	61,246	5,254
	1976	250,250	430	50	3,230	---	5,470	17,020	300	52,670	18,350	83,060	64,370	5,300
	TP	69,100	70	---	850	---	1,200	5,290	110	14,600	4,600	22,900	18,000	1,480
Aeronautical research and technology	1974	168,000	259	---	647	---	---	702	137	46,155	12,164	47,688	57,925	2,323
	1975	166,400	100	---	650	---	---	878	285	46,673	12,587	60,985	41,754	2,488
	1976	175,350	280	---	600	---	---	1,200	250	44,150	17,400	64,740	43,990	2,740
	TP	46,800	70	---	150	---	---	390	110	12,000	4,300	17,000	12,000	780
Space and nuclear research and technology	1974	66,307	700	---	2,820	---	4,650	13,555	---	6,984	1,300	13,154	19,859	3,285
	1975	71,365	75	50	2,310	---	5,656	16,215	61	9,073	1,000	14,667	19,492	2,766
	1976	74,900	150	50	2,630	---	5,470	15,820	50	8,520	950	18,320	20,380	2,560
	TP	22,300	---	---	700	---	1,200	4,900	---	2,600	300	5,900	6,000	700
OFFICE OF ENERGY PROGRAMS (Energy technology applications)	1974	4,693	430	---	875	---	---	2,008	---	---	28	316	1,036	---
	1975	4,435	380	---	550	---	230	2,500	---	225	---	90	460	---
	1976	5,900	1,875	50	250	---	225	2,500	---	175	---	75	750	---
	TP	1,500	375	25	50	---	75	675	---	75	---	25	200	---
OFFICE OF TRACKING AND DATA ACQUISITION	1974	244,000	---	---	---	---	175,113	46,833	5,544	---	1,978	200	---	14,332
	1975	248,000	---	---	---	---	176,200	48,400	6,200	---	2,600	---	---	14,600
	1976	243,000	---	---	---	---	169,100	51,500	5,100	---	2,400	---	---	14,900
	TP	66,400	---	---	---	---	45,300	15,300	1,400	---	600	---	---	3,800
OFFICE OF TECHNOLOGY UTILIZATION	1974	4,500	---	---	---	---	---	---	---	---	---	---	---	4,500
	1975	5,500	---	---	---	---	---	---	---	---	---	---	---	5,500
	1976	7,000	---	---	---	---	---	---	---	---	---	---	---	7,000
	TP	2,000	---	---	---	---	---	---	---	---	---	---	---	2,000
TOTAL BUDGET PLAN	1974	2,310,882	614,056	110,894	297,596	1,450	403,033	127,131	14,201	85,345	15,570	355,942	185,579	100,085
	1975	2,323,315	797,876	113,795	285,822	8,200	385,195	169,854	18,315	114,494	16,293	192,032	132,550	90,889
	1976	2,678,380	1,014,517	106,560	409,330	9,100	354,008	186,167	17,565	138,920	20,825	154,463	170,038	96,887
	TP	730,600	267,449	34,475	105,750	2,350	104,115	55,068	4,235	37,807	5,200	45,886	43,500	24,765

Note: Amounts shown for NSTL exclude funding for Earth Resources Laboratory, which is suballocated from JSC.
TP: Transition Period

SUM 14

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1976 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

MANNED SPACE FLIGHT PROGRAMS

Programs	Budget Plan				
	1974	1975		1976	Transition Period
		Budget Estimate	Current Estimate		
	(Thousands of Dollars)				
Space shuttle.....	$475,000	$800,000	$797,500	$1,206,000	$321,000
Space flight operations.	523,400	323,300	311,300	207,100	55,100
Advanced missions.....	1,500	1,500	1,500	1,500	500
Total.....	$999,900	$1,124,800	$1,110,300	$1,414,600	$376,600

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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

BUDGET SUMMARY

OFFICE OF MANNED SPACE FLIGHT — SPACE SHUTTLE PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Orbiter	$363,125	$647,500	$634,600	$877,300	$230,900
Main engine	82,307	92,300	92,300	135,500	36,000
Solid rocket boosters	8,567	22,600	22,600	76,200	18,000
External tank	18,100	26,000	34,000	66,100	15,100
Launch and landing	2,901	11,600	14,000	50,900	21,000
Total	$475,000	$800,000	$797,500	$1,206,000	$321,000
Distribution of Program Amount by Installation:					
Johnson Space Center	$357,102	$630,200	$622,113	$864,948	$227,265
Kennedy Space Center	2,901	11,600	14,000	50,900	21,000
Marshall Space Flight Center	110,311	147,700	149,687	278,400	69,200
National Space Technology Laboratories	700	1,000	1,000	1,900	500
Goddard Space Flight Center	---	---	68	100	25
Ames Research Center	175	---	---	---	---
Langley Research Center	174	---	28	52	10
Headquarters	3,637	9,500	10,604	9,700	3,000
Total	$475,000	$800,000	$797,500	$1,206,000	$321,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

OFFICE OF MANNED SPACE FLIGHT

SPACE SHUTTLE PROGRAM

SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Space Shuttle	Rollout of Orbiter No. 1	3rd Qtr 1976
	Approach and Landing Tests	4th Qtr 1977
	First Manned Orbital Flight	2nd Qtr 1979
	Developmental Flights	3rd Qtr 1979-Mid 1980
	Operational Shuttle	Mid-1980

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

OFFICE OF MANNED SPACE FLIGHT — SPACE SHUTTLE PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Shuttle is the key element of an economical space transportation system that will provide a wide variety of national and international users with routine 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 -- applications, scientific, military, and technological -- to and from low earth orbit. By offering versatility, economy, and ease of access to space, the Shuttle will open up new avenues of opportunity for expanding the down-to-earth returns from space and advancing the frontiers of science and technology. It will provide an economical transportation system for payload developers and users from United States Government agencies, private industries, universities, research organizations, and national and international organizations.

The Space Shuttle's design features and operational flexibility are the key to driving down the cost and complexity of payloads as well as space operations. The Shuttle will be able to retrieve as well as deploy satellites, to repair and redeploy them, to service or update them and to return them to earth for refurbishment and reuse. The Shuttle will also make rapid space rescue possible. In some instances, it may eliminate the need for space rescue by providing a means for timely delivery to orbit of replacement components.

The Shuttle system has four basic elements: the orbiter, the main engines, an external propellant tank and twin solid rocket boosters.

The Shuttle orbiter, with 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 stringent design constraints. Standard laboratory equipment, much of it off-the-shelf and relatively inexpensive, may be used in the construction of a payload. This key factor, reduction of payload complexity, will be a significant step in decreasing costs. The varied types of payloads that the orbiter can lift into orbit range from automated free flying satellites and space telescopes to fully equipped space laboratories with facilities for scientists and technicians to carry out orbital experiments and manufacturing processes in a comfortable shirt-sleeve environment.

Mission Profile

The Space Shuttle will be boosted into orbit 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 40 kilometers (km) (22 nautical miles), the solid rocket boosters burn out, are separated and descend by parachute to a soft splashdown in the ocean about 240 km (130 nautical miles) down range. They will then be recovered for refurbishment and reuse. The orbiter, powered by its three main engines, will continue on into space for another six minutes. At the end of that time, the engines will be shut down. At this point, just prior to orbital insertion, the external tank will be jettisoned. Following a ballistic trajectory, the empty tank will fall in a remote ocean area about 18,500 km (10,000 nautical miles) down range. The orbiter, firing its orbital maneuvering engines, will then enter earth orbit to perform its mission. After completing its mission, the orbiter will again fire its orbital maneuvering engines to deorbit and reenter the atmosphere at a high angle (about 34°) in a shallow flight path to minimize frictional heating. At 21 km (about 70,000 feet) altitude, the orbiter will begin the final maneuvering, align its approach and land.

The Space Shuttle will have a flight crew of three: the commander, the pilot, and a mission specialist. On some missions a payload specialist will be added to check out complete payloads and deploy them in space. In normal operations the Shuttle can carry up to seven people, including the crew, for periods up to seven days. They will experience forces no more than three times that of gravity (3-g forces) during launch and landing and can perform their work in shirt-sleeve comfort.

Status

All Shuttle system elements are under contract and the development is proceeding as planned. Many components of the Shuttle system have already been completed in FY 1975 and testing has been initiated. Funding for FY 1976 will permit the Shuttle prime contractors, the first and second tier subcontractors and their suppliers to continue manufacturing and testing components for the four basic elements of the Space Shuttle system. Fabrication of the major test articles, design of the launch processing system, and design of the solid rocket booster components and the recovery system are planned for FY 1976. Twenty-one subcontracts, valued at more than $10 million each, are now in effect and sixty subcontracts between $1 and $10 million each have been definitized. Even larger numbers of suppliers and small subcontractors will be part of the overall effort for FY 1976. The Shuttle is well into the hardware development and testing phase and several major milestones have been accomplished.

The Space Shuttle development is proceeding on schedule to meet the major milestones of first approach and landing test in 1977 and first manned orbital flight in 1979.

BASIS OF FUND REQUIREMENTS:

Orbiter

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$363,125	$647,500	$634,600	$877,300	$230,900

OBJECTIVES AND STATUS

The orbiter will be a reusable airplane-like vehicle with a versatile capability for multipurpose low earth orbital operations. It will have a payload bay measuring about 18 meters (60 feet) in length with a diameter of 4.5 meters (15 feet). With the two solid rocket boosters, the orbiter will be able to place up to 29,500 kilograms (65,000 lbs.) into a 185 kilometer (100 nautical mile) circular orbit, due east launch azimuth.

Orbiter No. 1 crew module fabrication was completed by the prime contractor, Rockwell International/Space Division, in FY 1975 and manufacture of the aft and mid-fuselage structures is nearing completion. Fabrication of the main propulsion test article was begun in early FY 1975 and should be completed on schedule in FY 1977. Orbiter No. 2 will have its Preliminary Design Review in late FY 1975 to verify the design approach and to establish the basis for proceeding with detail design and fabrication of ground test and flight hardware for the first manned orbital flight. The Preliminary Design Review for the carrier aircraft modification was completed in FY 1975. The thermal protection system development, during the fiscal year, has concentrated on obtaining high quality raw materials, such as carbon, for the leading edges and nose cap, sand for the silica tiles and frit for the protective outer coating. Methods of production and manufacturing procedures were also developed for the thermal protection system. The environmental control and life support system preliminary design has been completed and some development work and testing has been done on the components of this system, i.e., freon coolant loops, heat exchanges, cold plates, radiator panels, ammonia boliers, and pressure controls.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The difference between the 1975 budget estimate and the current estimate resulted from actions taken in 1974 to accelerate procurement of pacing equipment, supplies and materials. These actions were taken to maximize assurance of meeting key schedule milestones and to lessen the impact of inflation on the funding plans for FY 1975. In addition, $2.5 million was transferred to Construction of Facilities to provide for the increase in the amount required for the orbiter approach and landing test facilities, and initiation of the Shuttle/carrier aircraft mating facilities.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

During FY 1976 the prime contractor will continue design, fabrication and assembly of Orbiter No. 1 and begin to manufacture Orbiter No. 2. Orbiter No. 1 is being configured for the first approach and landing test to be conducted in 1977 at the Flight Research Center, Edwards AFB, California. Orbiter No. 2 will be configured for the first manned orbital flight, which is to be launched from the Kennedy Space Center in 1979. The major subcontractors for the mid-section, wings, vertical stabilizer, cargo doors, landing gear, nose section, leading edges for wing and vertical stabilizer, and tail fairing will complete fabrication and ship these components for Orbiter No. 1 to the assembly plant at Palmdale, California.

The Critical Design Review which is held when detail design is essentially completed to verify compliance with the system and technical requirements for those systems required for the Shuttle approach and landing tests will be held in FY 1976. Ground support equipment and the test station at Palmdale, California, will be completed by the last quarter of FY 1976 and ready for use in the checkout of Orbiter No. 1. Assembly of Orbiter No. 1 will be nearly complete by the end of FY 1976. The one-quarter scale model of the Shuttle will be completed in FY 1976 and subjected to ground vibration tests.

Final assembly of the crew module and basic airframe of the structural test article will be completed to allow test set-up activities and instrumentation installation to begin in FY 1976. In addition, fabrication and assembly will begin on the aft fuselage test article which will be utilized for vibro-acoustic testing.

The thermal protection system (TPS) for the orbiter is a major subsystem and a key development activity. This system is designed to attenuate the aerothermal heating on the external surface of the orbiter during ascent and reentry. During FY 1976, material characterization of both the low and high temperature reusable surface insulation will be completed. Development testing of representative pieces of the high temperature

reusable surface insulation from critical areas, and reusable carbon-carbon from the leading edges and the nose will be subjected to repeated reentry heating and environmental testing in FY 1976. The thermal protection system production facility for reusable tiles will become operational in early 1976 and production runs of these materials will be delivered during that fiscal year.

Avionics provides the electrical power and electronics to guide and control the Space Shuttle and is basic to its success. During FY 1976 the avionics hardware systems for the approach and landing test will be completed and installation will begin on Orbiter No. 1. These systems are: guidance and navigation, flight control, communications, display and control, instrumentation, data processing and electrical power distribution. Engineering integration of preproduction hardware (bread board/prototype) and software will be performed in FY 1976 at Rockwell International/Space Division. Software will continue to be developed and tested at Johnson Space Center and integrated with the avionics hardware systems for validation in the Center's Shuttle avionics integration laboratory.

In addition, FY 1976 requirements provide for developing software programs, modifying two Shuttle training aircraft and the Shuttle carrier aircraft, and updating automatic checkout equipment. Technical design support will continue to be provided for the avionics systems and the ground testing of subsystems and components will be continued at Government facilities in those cases where the tests cannot be performed cost effectively at the contractor's facilities. Funding in FY 1976 will also be used for Government-furnished equipment, which includes the astronaut life support assembly and spacesuits for extravehicular activity, the orbiter aeroflight simulator, the Shuttle mission simulator, and the Shuttle procedures simulator, as well as testing of the orbital maneuvering system engine at the White Sands Test Facility in New Mexico; the accomplishment of systems management tasks and environmental effects studies; and contract administration to be performed by the Defense Contract Audit Service.

During the transition period, installation and checkout of Orbiter No. 1 subsystems will be continued, leading to the rollout of the vehicle, which is currently targeted for the third quarter of 1976. Fabrication of the orbiter main propulsion test article will be continued, as will the structural fabrication and subassembly of Orbiter No. 2. Delivery of the Shuttle training aircraft is also expected to take place during this period.

Main Engine

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$82,307	$92,300	$92,300	$135,500	$36,000

OBJECTIVES AND STATUS:

A cluster of three high chamber pressure hydrogen/oxygen engines, each with a 470,000 pound vacuum thrust level, will be used on the orbiter. The high chamber pressure at which these engines operates is a major technological advancement. This high chamber pressure allows the use of a higher expansion ratio nozzle and results in a more efficient operating engine without increasing size. Another new dimension has been added to the Space Shuttle main engine, that of long life. It will be the first large liquid rocket engine specifically designed to be reusable.

In FY 1975 the main engine fuel and oxidizer preburners were successfully tested at Santa Susana, California. Component testing of the turbopumps and thrust chamber are scheduled for the latter half of FY 1975. The integrated subsystem test activities to be performed at the National Space Technology Laboratories (NSTL), formerly the Mississippi Test Facility, will begin near the end of FY 1975 and will continue in FY 1976. The rack-mounted engine controller will be utilized for the integration tests at NSTL. Fabrication work on major components of the main engine is the primary contractor effort in FY 1975.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

During FY 1976 the prime contractor, Rocketdyne, will continue testing and fabrication of the major subsystems of the Space Shuttle main engine. Subsystems being tested at Santa Susana include the ignition system, thrust chambers, fuel and oxidizer turbopumps and the preburners. The first engine firing at rated power level (RPL) will take place at NSTL in mid-FY 1976 and will be followed by the first throttling test over the rated power level range. The main propulsion test article will be in fabrication during FY 1976 to support the integrated test activity scheduled for FY 1977. Long lead time procurement of material and hardware for the flight engines will also be initiated in FY 1976 to allow manufacture to begin in FY 1977.

In addition, logistics support will be provided for the main engine efforts. This support will include procurement of propellants for test firing the engine and its various components, such as preburners and turbopumps.

In the transition period the fabrication of flight engine components is scheduled to begin following the main engine Critical Design Review.

Solid Rocket Boosters

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$8,567	$22,600	$22,600	$76,200	$18,000

OBJECTIVES AND STATUS

The booster element of the Space Shuttle system consists of two reusable solid rocket boosters approximately 3.6 meters (12.2 feet) in diameter and 45.5 meters (149 feet) long, attached to the external tank. The solid rocket boosters, burning in parallel with the orbiter's main engines, will provide the combined thrust necessary from lift-off to booster staging. At staging, the solid rocket boosters will be released to descend by parachute into the ocean some 240 km (130 nautical miles) from the launch site. They will be recovered and returned to land for refurbishment and reuse.

Thiokol, Wasatch Division, is the contractor for the solid rocket motors. The booster system elements, such as the recovery system, the thrust vector control system and the aft skirt will be procured separately. The Marshall Space Flight Center will perform designated systems integration tasks and has the responsibility for total systems integration of the solid rocket booster effort.

In FY 1975 the incremental Preliminary Design Review of structural drawings for the nose cap, frustrum, forward skirt and aft skirt was completed as was the solid rocket booster Preliminary Design Review. A technical problem of plume impingement on the orbiter thermal protection system during the firing of the solid rocket separation motors was corrected by moving the separation motors up on the frustrum, thus increasing their thrust and decreasing their firing time. Most of the tooling for fabrication of the solid rocket motor cases has been defined and procurement is underway. A prototype case segment was completed in mid-FY 1975 and has been used to demonstrate fabrication, heat treatment and machining processes for the production run. Selection of the subcontractors for the manufacturing of remaining components of the solid rocket booster will be completed in FY 1975 with the exception of the recovery system.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

The prime contractor will begin fabrication of development motors in FY 1976 to support first firings in FY 1977. Subcontractor effort will proceed with manufacture, heat treatment and machining of the solid rocket motor cases. A prototype flexible bearing for the thrust vector control (TVC) system will be fabricated and tested in FY 1976. The design of the TVC actuators will also be completed. Fabrication of actuator development hardware and development testing will be initiated. Hardware fabrication for the separation motors will begin in FY 1976. Fabrication of major structural components, including the nose cap, forward skirt, aft skirt and attach system will begin in FY 1976. Separation motor testing will be conducted near the end of FY 1976.

Funding during the transition period will provide for continuing work on the solid rocket motor cases, including propellant processing, bonding studies, grain shaping and fabrication of structural components for the solid rocket booster.

External Tank

	1975			
	Budget	Current		Transition
1974	Estimate	Estimate	1976	Period
	(Thousands of Dollars)			
$18,100	$26,000	$34,000	$66,100	$15,100

OBJECTIVES AND STATUS:

The external tank is a single assembly approximately 8.5 meters (27.5 feet) in diameter, and 47 meters (154 feet) long. It contains liquid oxygen and liquid hydrogen tanks and is mounted below the orbiter and between the solid rocket boosters. Other major elements include propellant pressurization, external thermal protection and attachment hardware. The external tank will contain all the liquid oxygen and liquid hydrogen propellants consumed by the main engines of the orbiter from lift-off to main engine cut-off just prior to orbital insertion. Following main engine cut-off, the external tank will be separated from the orbiter and will coast through a ballistic trajectory to impact within a designated remote ocean area.

The design and development contractor for the external tank is the Martin Marietta Corporation/Denver Division. The design and development activities are proceeding in the Government-owned Michoud Assembly Facility, New Orleans, Louisiana.

Since the external tank represents the only expendable element in the Shuttle operational system, every effort is being made to reduce the unit cost to a minimum. The prime contractor will use the latest production techniques and the lowest cost materials consistent with safety and reliability.

Early in FY 1975, NASA conducted the external tank Preliminary Design Review and the thermal protection system was changed to meet the higher ascent temperatures predicted for the latest launch envelope. Several tests of the spray-on foam insulation applied to a 10-foot diameter test tank were completed to verify the application process. Procurement of tooling for the major test article was initiated and installation at the Michoud Assembly Facility is to begin near the end of FY 1975.

CHANGES FROM FY 1975 BUDGET ESTIMATES:

The original FY 1975 budget estimate differs from the current estimate in that NASA and the external tank contractor have now negotiated a definitized contract, with earlier funding required to integrate the tank into the overall schedule. The design, development, test and evaluation cost is consistent with NASA's overall estimate.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

The Critical Design Review for the external tank will be held in mid-FY 1976. Fabrication and assembly of the structural test articles (the intertank and the liquid oxygen and liquid hydrogen tanks) will begin in FY 1976, leading to delivery of the test article to the Marshall Space Flight Center testing facilities in mid-FY 1977. Fabrication of the main propulsion test article tank will begin during FY 1976. The main propulsion test article will be integrated and tested with the orbiter aft fuselage and the three propulsion test engines at the National Space Technology Laboratories. Welding facilities and equipment will be completed and installed at Michoud in the first half of FY 1976. Long lead time procurement of selected materials for the first increment of flight tanks will be continued during FY 1976. Tooling required for the fabrication and assembly of the flight tanks will be completed and certified before the beginning of fabrication in FY 1977. Project support activities during FY 1976 will provide for the restoration and modification of existing fabrication equipment at the Michoud Assembly Facility and activation of structural test facilities at the Marshall Space Flight Center.

In the transition period, the contractor will complete the assembly of the intertank and the liquid oxygen tank for structural article tests. Fabrication and assembly of the main propulsion test article will also be continued.

Launch and Landing

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$2,901	$11,600	$14,000	$50,900	$21,000

OBJECTIVES AND STATUS:

New launch processing equipment and operational techniques are required to assure that the Shuttle ground operations are compatible with vehicle operation requirements, including turnaround times, launch rates and launch cost objectives. The launch processing system (LPS) will consist of two major subsystems, the checkout, control and minor subsystem (CCMS), and the central data subsystem (CDS). The CCMS will utilize a distributed processing scheme where consoles, each containing a small computer, will perform in parallel within their assigned function. The CDS will provide support to the CCMS and will consist of two large scale computers (primary and secondary) with shared access storage devices and related communications processors, interface and peripheral devices.

At Kennedy Space Center, Phase I of the orbiter landing facility is nearly complete. This phase, using Construction of Facilities funds, includes land clearing, digging the runway out to establish a solid base and installing drainage systems and runway lighting system conduit. Detailed design for facility modifications to Launch Complex 39 and for the construction of a new orbiter processing facility is also nearly complete. Software analysis has been proceeding for most of the past year to verify the procedures for an automated launch checkout system utilized in the LPS.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The additional FY 1975 funding requirements resulted from a decision to utilize launch processing system checkout equipment in the Solid Rocket Booster electrical and instrumentation verification test and bench maintenance equipment tests.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Design effort on the launch processing system that began in FY 1975 will be continued in FY 1976. The Preliminary Design Review will be conducted early in FY 1976 and will be followed later in the fiscal year by the Critical Design Review.

System engineering and integration for the launch processing system will be a major effort at the Kennedy Space Center during FY 1976. Programming of computers and program validation will be conducted in the last half of the fiscal year. Procurement of software, mini-computers for the CCMS, peripheral devices such as cartridge disc systems, process data disc systems, line printers and readers, and consoles for this equipment is scheduled for FY 1976. Also planned is the initial procurement of major components of the CDS large scale computers.

Major engineering support services tasks to be performed or completed in FY 1976 include design, procurement and installation of unique ground support equipment (GSE) for the approach and landing tests; design and procurement of unique GSE for support of the first manned orbital flight; preparation of Space Shuttle launch and landing engineering specifications and standards; field surveys and field liaison engineering at the launch and landing site; preparation of preliminary engineering reports and conceptual engineering reports and other engineering data; systems engineering and integration support between ground support systems and other identified Space Shuttle operational requirements; and establishment of an engineering documentation center where technical documentation will be prepared, stored, and distributed.

During the transition period, work will be continued on the launch processing system, the installation of unique ground support equipment and operations of the engineering documentation center.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

BUDGET SUMMARY

OFFICE OF MANNED SPACE FLIGHT — SPACE FLIGHT OPERATIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Development, test and mission operations...	$220,200	$175,200	$170,200	$166,100	$43,200
Space life sciences....	21,000	18,000	18,000	19,000	5,500
Mission systems and integration.....	15,500	15,500	13,500	22,000	6,400
Apollo Soyuz Test Project.....	90,000	114,600	109,600	---	---
Skylab.....	176,700	---	---	---	---
Total.....	$523,400	$323,300	$311,300	$207,100	$55,100
Distribution of Program Amount by Installation:					
Johnson Space Center...	$228,574	$135,709	$130,600	$101,750	$27,000
Kennedy Space Center...	103,700	89,800	86,725	38,950	10,200
Marshall Space Flight Center.....	167,006	79,430	75,300	48,550	12,750
National Space Technology Laboratories..	750	6,000	7,000	7,000	1,800
Goddard Space Flight Center.....	848	250	376	340	100
Jet Propulsion Laboratory.....	645	775	500	600	200
Wallops Flight Center..	48	---	---	---	---
Ames Research Center...	9,720	7,536	8,065	8,450	2,525
Flight Research Center.	100	100	106	75	---
Langley Research Center	998	550	69	185	75
Lewis Research Center..	250	250	200	250	200
Headquarters.....	10,761	2,900	2,359	950	250
Total.....	$523,400	$323,300	$311,300	$207,100	$55,100

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

OFFICE OF MANNED SPACE FLIGHT — SPACE FLIGHT OPERATIONS PROGRAM

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Apollo Soyuz Test Project	International Docking Test	July 1975

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

OFFICE OF MANNED SPACE FLIGHT — SPACE FLIGHT OPERATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Flight Operations program includes the developmental and supporting activities conducted under development, test and mission operations; space life sciences; mission systems and integration; and the Apollo Soyuz Test Project. The highly successful Skylab program, which was completed in 1974, was funded under the Space Flight Operations program.

Development, test and mission operations encompasses the basic engineering, research and test operations conducted at the Johnson Space Center, the Kennedy Space Center, the Marshall Space Flight Center, and the National Space Technology Laboratories in support of manned space flight programs, together with the provisions for crew training, and launch, flight, and operational support required for space flight missions.

Space life sciences complements ongoing and planned space activities through ground-based and flight research projects involving studies of man as an operator and controller of hardware in space. Space life sciences provides for the requisite advanced technology development of systems designed to support and protect the life of man or to extend his capabilities in space.

Mission systems and integration encompasses work essential to the planning and preparation for future manned space flights. The principal areas of activity are: payload integration and mission analysis, Spacelab studies and concept verification testing, advanced development, and the definition studies for an interim upper stage and Space Tug to meet NASA requirements.

The U.S. and the USSR agreed in May 1972 to jointly implement the Apollo Soyuz Test Project (ASTP) to develop and test a compatible system for rendezvous and docking of future manned spacecraft and stations that would be suitable for use as a standard international system. The ASTP is a flight experiment involving the rendezvous and docking of a manned Apollo spacecraft with a manned Soyuz spacecraft. The Soyuz spacecraft will be launched from the USSR. The Apollo spacecraft will then be launched from the U.S. and will rendezvous with the Soyuz spacecraft in orbit where joint docked operations, including crew transfer and in-flight experiments will be accomplished. The Apollo Soyuz Test Project requires no FY 1976 new obligations authority

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All the planned objectives for the Skylab program were successfully accomplished. Fiscal Year 1974 was the last year of funding requirements for the Skylab flight program.

BASIS OF FUND REQUIREMENTS:

Development, Test and Mission Operations

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Research and test operations	$61,024	$57,100	$54,500	$55,400	$14,500
Data systems and flight operations	65,356	40,900	40,900	40,000	10,400
Operations support	42,906	43,100	43,100	44,300	11,500
Launch systems operations	50,914	34,100	31,700	26,400	6,800
Total	$220,200	$175,200	$170,200	$166,100	$43,200

OBJECTIVES AND STATUS:

Development, test and mission operations (DTMO) provides the equipment, supplies and contractor support to maintain the basic capabilities necessary to conduct manned space flight research and development at the Johnson Space Center, the Kennedy Space Center, the Marshall Space Flight Center, and the National Space Technology Laboratories. The nucleus of all Manned Space Flight activities rests in the Centers with their complement of civil service personnel. This complement has been held to the minimum required to provide essential technical and management expertise. These capabilities are augmented through the use of more than 30 research and development support contractors to provide critical skills not otherwise available.

In-house research and development capabilities are those common to all Manned Space Flight programs being conducted or proposed. These in-house capabilities must exist to provide early project definition, including conceptual design, project specifications, advanced development, and research and technology. These skills are also required to provide engineering support for in-depth technical examination of the work performed by the prime and major subcontractors on major programs, such as the Space Shuttle, and to provide backup design, testing and analysis in high technology areas of design and development. In addition to these basic overall capabilities, in-house efforts are also performed to support specific programs. Examples

are specific program tasks resulting in required end items that have not been placed under prime contract but are essential to the successful completion of the program.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The decrease is the result of Congressional action on the FY 1975 Authorization. The amount authorized was $5 million below the FY 1975 funding requirements for development, test, and mission operations.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

The Fiscal Year 1976 and transition period funding will continue to support manned programs, including Shuttle, as well as activities conducted under space life sciences, mission systems and integration, and advanced missions. The FY 1976 development, test and mission operations funding requirements will also be sued for approximately 6,000 support contractor personnel. These people are an essential part of NASA' in-house capability required to pursue ongoing and planned manned space flight efforts.

Research and Test Operations

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Engineering and test	$56,099	$52,900	$50,300	$50,900	$13,300
Reliability, quality and safety.....	4,925	4,200	4,200	4,500	1,200
Total.....	$61,024	$57,100	$54,500	$55,400	$14,500

OBJECTIVES AND STATUS:

Research and test operations support a broad spectrum of technical engineering, scientific, medical, reliability and quality assurance and safety support operations. These activities complement the work of the major development contractors located in contractor-owned plants and Government facilities across the nation.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The current FY 1975 estimate for the research and test operations activities reflects an adjustment required to absorb part of the $5 million Congressional Authorization reduction in DTMO. As a result of this Congressional action, the FY 1975 funding for engineering and test efforts is $2.6 million below the amount requested. The reduction required a cutback of originally planned level of engineering and test support.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

The FY 1976 funding requirements for research and test operations will provide for support of the rapidly increasing Space Shuttle development activities and the efforts complementing the European Spacelab development. In addition, the requirements will support continued Space Shuttle and Spacelab utilization planning. Research and test operations support will also be provided to the space life sciences, concept verification testing, and advanced development activities, as well as the advanced missions studies.

Specific examples of FY 1976 Space Shuttle support to be provided at the Johnson Space Center include: (1) the continuation of Shuttle orbiter technology and definition testing for propulsion systems, attitude control and translation systems, thermal protection systems, structural systems and materials, and Shuttle avionics integration; (2) in-house support to the Space Shuttle contractor by providing orbiter antenna test and evaluation, communications and tracking system ground testing, selected components test and evaluation, sensor studies and evaluation, and development of orbiter displays and controls, orbiter data processing system hardware, and orbiter performance monitoring systems.

At the Marshall Space Flight Center, FY 1976 funding provides for (1) analysis of the dynamics of re-entry of the solid rocket booster, studying recovery parachute aerodynamics, performing structural analyses/trade-off studies for design optimization, establishing procedures for solid rocket motor failure mode and effects analysis, and supporting the development of solid rocket motor design requirements; (2) support to the Shuttle main engine development through preparation and testing of materials, evaluation of ground handling and operation procedures, and establishment of a hybrid simulation of the engine controller/actuator system; and (3) support of the external tank including performing stress analysis of structures, conducting trade-off studies to optimize structural design, and performing cost optimization trade-off studies of the propulsion systems.

In addition, the FY 1976 research and test operations funds which are to be provided to the Johnson Space Center and the Marshall Space Flight Center will support (1) in-house efforts to demonstrate and verify various manned and automated shuttle payload designs and operational concepts, including Spacelab oriented trade-off studies, and performing man/systems integration and operations systems analyses; (2) biomedical activities related to shuttle spacecraft design, operational support to manned space flight operations such as flight crew health care, developing and implementing space flight medical studies, and conducting primary and basic research in space life sciences.

During the transition period, research and test operations funding will provide continued engineering and technical support to Shuttle development analysis and testing, as well as support to in-house Spacelab and payload development and utilization activities.

Data Systems and Flight Operations

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Ground-based flight data systems.....	$20,905	$18,300	$18,300	$15,500	$4,000
Flight simulation and development data systems.....	38,458	16,300	16,300	18,100	4,700
Spacecraft and aircraft operations	5,993	6,300	6,300	6,400	1,700
Total.....	$65,356	$40,900	$40,900	$40,000	$10,400

OBJECTIVES AND STATUS:

This project, formerly titled Crew and Flight Operations, has been reconfigured to support the requirements of the Space Shuttle at the Johnson Space Center.

Data systems and flight operations includes the requirements definition, design, implementation, and checkout of hardware and software modifications to the Johnson Space Center's Mission Control Center (MCC) and the Real Time Computer Complex (RTCC), and for the operation and maintenance of these facilities during preparations for mission support and during the flight missions.

Flight simulation efforts will require operation and maintenance of full-mission and part-task simulations for flight procedures development, as well as operation of the Johnson Space Center's Central Data Computation Facility which is required to support center-wide activities in mission analysis, systems engineering, development and test functions for the Shuttle program.

Data systems and flight operations also provides for the development of Shuttle flight control and recovery plans and procedures, production of flight plans, flight data files, crew procedures, and other elements of the data base required for crew activities in space flight; operation and maintenance of space flight readiness training aircraft; and related flight data management.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In FY 1976 major efforts will involve the preliminary definition of operational concepts and related MCC and RTCC requirements for the flight support and flight data management functions during the operational flight test period of the Space Shuttle program. During FY 1976, this effort will also include the operation of the Software Development Laboratory, which is comprised primarily of existing RTCC systems and is used to develop and validate the Shuttle orbiter flight software.

In FY 1976 efforts will emphasize flight data processing support and mission and systems design, and performance studies for the Shuttle.

Other operations activities which will be supported in FY 1976 are maintenance, modification, and engineering support services relating to the T-38 space flight readiness training aircraft and the KC-135 zero-G aircraft.

During the transition period, the funding will cover requirements for Space Shuttle support, including data processing plans, mission and systems design and performance studies, software modifications, and flight simulation activities.

Operations Support

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$42,906	$43,100	$43,100	$44,300	$11,500

OBJECTIVES AND STATUS:

Operations support provides contractor effort and related supplies and equipment to operate and maintain on-site technical services at the Johnson Space Center, the Marshall Space Flight Center, the Kennedy Space Center, and the National Space Technology Laboratories. These supporting technical services are also provided for the Johnson Space Center's off-site operations at the White Sands Test Facility in New Mexico and for the Marshall Space Flight Center's off-site operations at the Michoud Assembly Facility and the Slidell Computer Complex in Louisiana.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Fiscal Year 1976 funding will provide for the maintenance of highly technical facilities and equipment,

chemical cleaning, engineering design, technical documentation, preparation of technical reports, telecommunications, component fabrication, photographic support and logistics support.

A cross-section of specific services required in FY 1976 includes: (1) preparing for final publication of the mission-related documents for ASTP flight control operational requirements; (2) operation of shops to do metal furbishing, anodizing, plating, stripping, and etching of selected items of in-house fabricated hardware; (3) engineering, installation, operation and maintenance of closed circuit fixed and mobile television required for support and surveillance of tests; (4) photographic services including film processing and photographic mission support; (5) fabrication of breadboards, scaled replicas of flight items and selected hardware for Shuttle technical efforts; (6) technical documentation services, telecommunications, and graphics; (7) technical services in support of center operations, including receipt, storage, issue of research and development supplies and equipment, and transportation services; and (8) management services in support of Center operations, including data management, microfilming, and distribution of technical documentation.

Fiscal Year 1976 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 materials and components testing, and orbital maneuvering systems test support for the Shuttle program; operation and maintenance of the computer systems at the Slidell Computer Complex; and a basic level of operation and maintenance of the Michoud Assembly Facility where the external tanks of the Shuttle are to be fabricated and assembled.

In addition, the FY 1976 operations support funds will provide the basic level of support to the National Space Technology Laboratories, which is engaged in the integrated component testing of the Space Shuttle main engine, static test firing of the main engine, and qualification of the main propulsion test article.

Transition period funds will provide a continuation of effort needed to operate and maintain technical support services required for all manned space flight programs and activities.

Launch Systems Operations

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Mechanical ground systems	$25,893	$19,900	$19,000	$15,700	$4,000
Electrical/instrumentation systems	25,021	14,200	12,700	10,700	2,800
Total	$50,914	$34,100	$31,700	$26,400	$6,800

OBJECTIVES AND STATUS:

Launch systems operations at the Kennedy Space Center provides for the operation of the checkout and launch facilities, complexes and associated ground support equipment as well as the highly technical services required to support the test, checkout and launch of space vehicles and payloads.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The current estimate for FY 1975 launch systems operations reflects a decrease of $2.4 million. This adjustment was necessary to absorb part of the $5 million Congressional authorization reduction in development, test, and mission operations funding. The FY 1975 mechnaical ground systems effort is $900,000 below the level originally planned and the electrical/instrumentation systems efforts are programmed at $1.5 million below the original plan.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

The beginning of FY 1976 will witness the final checkout activities and launch of the Apollo Soyuz Test Project mission which will have utilized KSC's launch processing capabilities for assembly and integration of the flight hardware for the Apollo Soyuz Test Project.

Fiscal Year 1976 funding provides for mechanical ground system activities involving maintenance and modification of launch complex facilities and related equipment such as mobile transporters, mobile launchers, converter compressor facility, mobile service structure, altitude chambers, propellant loading systems, pneumatics, and Vehicle Assembly Building mechanical systems. In addition, launch related services, such as propellant handling, life support, technical shops, and chemical cleaning labs, will continue to be maintained in an appropriate mode of readiness to support reconfiguration activities to meet the Space Shuttle requirements.

Fiscal Year 1976 funding also provides for the maintenance and modification of electrical/electronic and launch instrumentation systems such as automatic checkout equipment, operational voice and TV communications, computation, measurements, telemetrics, and other electrical/electronic systems.

During the transition period, the funds requested will be devoted to maintaining, reconfiguring, and preparing KSC's launch facilities and systems to accommodate the Space Shuttle flight hardware and payload systems, including the installation of newly designed ground support systems.

Space Life Sciences

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)				
Space life research...	$10,500	$8,900	$8,900	$8,900	$2,400
Life support and protective equipment...	7,000	6,000	6,000	6,000	1,500
Bioinstrumentation and man-machine technology.....	3,500	3,100	3,100	3,100	1,150
Life sciences dedicated Spacelab mission common operating research equipment (CORE)....	---	---	----	1,000	450
Total.....	$21,000	$18,000	$18,000	$19,000	$5,500

OBJECTIVES AND STATUS:

The Space Life Sciences program provides the understanding and technology necessary to determine human capabilities and limitations in the space environment and to develop a technology base for the various types of systems which will permit people to live and perform effectively in a space environment. With the advent of Space Shuttle operations and the inclusion of scientist passengers in the Shuttle/Spacelab program, new selection criteria are necessary. Biomedical data to support these criteria must be obtained, as well as methods for the prediction of potential medical changes during flight.

The primary areas of activity in the Space Life Sciences program are: space life research, life support and protective equipment, bioinstrumentation and man-machine technology, and the Common Operating Research Equipment (CORE) concept to be used in the life sciences dedicated Spacelab missions. This multi-science and engineering technology program is a continuum which starts from ground-based research and is carried into flight experiments and verifications. Biomedical problems are studied in those organisms appropriate for each task which range from tissue cultures to the human body. Specialized instrumentation and unique accommodations necessary to conduct this work are developed and tested.

Life sciences also provides advanced technology and development related to life support, protective, and other systems required to support men and women and to extend their capabilities in space. Major program emphasis is directed toward the development of information which can be translated into design data and criteria for advanced space systems and mission operations. These data are to provide the criteria for choosing Shuttle crew members and scientist passengers.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In Fiscal Year 1976, emphasis will be placed on the definition and evaluation of experiments for the Spacelab; spacesuit development for the Space Shuttle; and bioinstrumentation research. Studies will also be undertaken on design and development of common operating research equipment, which will be utilized in Spacelab missions dedicated to life sciences.

The transition period funding provides for continuation of research, test, and evaluation efforts and completion of engineering and study efforts necessary to develop the common operating research equipment design.

Space Life Research

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$10,500	$8,900	$8,900	$8,900	$2,400

OBJECTIVES AND STATUS:

Space life research activities focus on ground-based and space flight research designed to enhance the ability to function effectively and safely during space flight and to conduct research using the unique environment of space to support and advance earth-based science. This multi-disciplinary research program encompasses medical, behavioral and biological

research, as well as definition of space flight biomedical experiments. The primary objective is to maintain a research base investigating all pertinent aspects of known and anticipated problems of human response to space flight and to provide rapid response to new problems as they arise.

Carefully controlled biomedical experiments were performed during the Skylab missions, which were essentially completed in 1974. This documentation was analyzed and resulted in a FY 1975 program which emphasizes specific areas requiring further study, such as motion sickness, cardiovascular deconditioning, mineral loss, muscle mass loss, and red blood cell loss. In addition, physiological and psychological criteria are being developed for use in selecting crew members and scientist passengers for Space Shuttle missions.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

During FY 1976, emphasis will be placed on ground-based, life sciences research related to the Space Shuttle. Studies of human beings and small animals will be conducted under various stress environments, including parabolic aircraft flights and centrifugation. These studies will include investigation of semicircular canal and otolith organ interactions and their relation to vertigo and motion sickness; body fluid shifts in response to different gravity forces; and loss of calcium and the structural integrity of bone under conditions of disuse or loss of gravitational force. Fiscal Year 1976 funding will also provide for the definition and evaluation of animal and plant experiments for flight in the Spacelab.

The transition period funds will support continued investigations in these key life sciences research areas.

Life Support and Protective Equipment

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$7,000	$6,000	$6,000	$6,000	$1,500

OBJECTIVES AND STATUS:

The objectives of the life support and protective equipment efforts is to enhance the safety and performance of the crew and scientist passengers during Shuttle/Spacelab missions. Major areas of emphasis range from development and testing of improved life support and safety systems to development of more effective life support equipment. Improved reliability, maintainability, and operational characteristics are key goals in these efforts.

In FY 1975, advanced techniques are being developed to improve the extra-vehicular spacesuit design concepts. Advanced manufacturing techniques and modular "universal fit" spacesuit configurations are being developed to reduce suit costs and to simplify suit design for the Space Shuttle. Significant advances are being made in the cooling garment used under the spacesuit to keep the body temperature within acceptable physiological limits. Improved waste management systems are also being developed for use in space. These systems are compatible with either male or female use. In addition, a silver ion sterilization system, designed to purify the drinking water generated by the fuel cells on the Shuttle, has been completed. A new "Flash Evaporator" concept for simple and reliable heat rejection in space is also being developed.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

The FY 1976 life support and protective equipment efforts will focus on several critical areas: improved spacesuit joints and bearings to provide more mobility and comfort; new materials and fabrication techniques to provide increased strength and life at decreased costs; definition of a low-cost life support and waste management system for animal and specimen-holding facilities in the Spacelab; integration and testing of components of a Spacelab atmospheric contaminant sensor; and completion of testing of advanced concept breadboards of water reclamation and oxygen generation subsystems. Based on the results of this work, flight experiments will be prepared for future Shuttle payloads to demonstrate that these concepts will operate efficiently and reliably in space.

Funding during the transition period will be used for maintenance of research, test and evaluation efforts for those necessary life support subsystems and components approaching the design phase.

Bioinstrumentation and Man-Machine Technology

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
$3,500	$3,100	$3,100	$3,100	$1,150

OBJECTIVES AND STATUS:

Bioinstrumentation and man-machine technology provides for the development of technology and procedures for the measurement of physiological, medical and performance responses of human beings and other selected life species in the space environment. It also includes studies for advancement of technology in the use of people in man-machine systems; and for augmentation of human capabilities, through the use of devices such as teleoperators to service orbiting space vehicles, and to support experiments and space exploration.

Bioinstrumentation technology advancements in FY 1975 will result in a prototype blood analysis system to provide inflight, real time measurements of blood constituents, a one-dimensional ultrasonic-bone densitometer utilizing a dual photon source for measurement of bone width and mineral content. The assembly, installation, checkout and acceptance testing of a remote health care delivery system, analogue of a space health care system, were completed, and routine operations have been initiated.

In the man-machine technology area, an extravehicular activity (EVA) cost model was completed. This model will be used to study equipment interface requirements and system trade-offs in the performance of operational or emergency tasks. EVA work station conceptual designs, which are needed in studies of servicing Shuttle payloads and inspection of the Shuttle vehicle, were also generated. Teleoperator achievements produced new force sensing devices for the tongs of the manipulator and effectors and have opened a new area of study concerning force feedback. This advancement will provide firmer control over remote-servicing operations and handling of payloads. A visual system, producing a 3-D display effect, was developed using low-cost, non-stereo cameras and a specially constructed lens. The system is undergoing human factor evaluation under laboratory conditions. A control system designed to precisely maneuver remote manipulators has also been developed and installed in a laboratory engineering model.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In FY 1976, the bioinstrumentation program will emphasize the development of a urine volume measurement and sampling system, equipment for emergency intravenous injection of fluids and microminiaturized equipment to measure heart dynamics. Instrument design concepts will be studied and prototypes will be produced to measure cardiovascular, circulatory, metabolic, respiratory, musculoskeletal and other physiological functions where the data are important to the understanding of the body's adaptation to the weightless environment.

In FY 1976, the man-machine technology activities will include the definition and enhancement of the human's role in payload support related space activities. Conceptual designs of mobility and restraint systems will be initiated for activities in the Shuttle payload bay and Spacelab. Technology efforts will continue on the remote control of manipulators. Also included will be the development of image enhancement, and touch and proximity sensing devices essential in the interface between the human and the remotely controlled machine. System simulation of a conceptual teleoperator mission will focus on resolution of man-machine problems associated with servicing tasks.

In the transition period, funds are identified to provide for the continuation of the evaluation of breadboard bioinstrumentation technology for application to biomedical studies and flight experiments to be considered for Spacelab.

Life Sciences Dedicated Spacelab Mission
Common Operating Research Equipment (CORE)

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
---	---	---	$1,000	$450

OBJECTIVES AND STATUS:

The Common Operating Research Equipment project will provide the laboratory equipment needed to outfit the ESRO-developed Spacelab for life sciences experimenters. In this manner their experimental requirements will be satisfied except for research specimens and any unique, specialized equipment. The laboratory will be outfitted and integrated in modular fashion on racks with essentially off-the-shelf equipment. It will consist of equipment commonly used by all life sciences researchers, along with other laboratory support capabilities, such as specimen-holding facilities, storage, power, and surgical operating capability. The design provides for easy and rapid change of research equipment, routine refurbishment, and easy transfer from one Spacelab to another.

The proposed experiments will utilize subjects which range from tissue cultures to human beings. These experiments are required to gain information on life sciences questions associated with manned space missions. In addition, basic research will be conducted using zero gravity as a tool for identifying life systems functions which are altered as a result of the normal influence of the earth's gravity. The scientists onboard the Shuttle will be able to perform and adapt their experiments while in orbit and to consult with their collegues on the ground.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In FY 1976, two parallel contractor definition (Phase B) studies will be undertaken to provide more indepth engineering data and refined cost data as the basis for management decisions on final design and development (Phase C/D).

During the transition period, funds will be used to maintain an orderly completion of sequential engineering and study efforts. These activities are necessary to develop a common operating research equipment design that is both cost-effective and responsive to the requirements of biomedical flight experimentation.

Mission Systems and Integration

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Payload integration and mission analysis.....	$5,500	$5,500	$5,000	$6,000	$1,800
Spacelab/concept verification testing.....	2,500	2,500	2,000	6,100	1,900
Advanced development	7,500	6,000	5,500	6,500	2,000
Interim upper stage/ Space Tug.....	---	1,500	1,000	3,400	700
Total.....	$15,500	$15,500	$13,500	$22,000	$6,400

OBJECTIVES AND STATUS:

Mission Systems and Integration program activity is classified into four major areas of effort: Payload Integration and Mission Analysis, Spacelab/ Concept Verification Testing, Advanced Development, and Interim Upper Stage/Space Tug.

The study and analytical effort under Payload Integration and Mission Analysis assures hardware and operational compatibility between the payloads and the payload carriers, such as the Space Shuttle, the Spacelab, and the Interim Upper Stage/Space Tug. It also provides low cost, standardized, reusable equipment to accommodate a wide range of payloads.

Spacelab activities support the European Space Research Organization (ESRO) Spacelab development effort with engineering and operations studies in such areas as payload safety, accommodations, operations and logistics. In addition, development of a crew transfer tunnel and procurement of various mockups and other ground support equipment are being initiated. The concept verification testing effort deals with interface testing and verification of operational concepts resulting from the Spacelab studies.

Advanced development is directed toward development of critical and long-lead items, experimental systems and operational techniques, as well as the establishment of design and technology requirements for potential future development programs.

The Interim Upper Stage (IUS)/Space Tug effort is twofold. The IUS will be used to transport payloads during the early Shuttle missions to high energy and escape orbits. The IUS is being developed by the U.S. Air Force. NASA supports this development through studies which will define NASA and other non-DoD requirements. The Space Tug is designed with an increased performance to be used with later Shuttle missions. Activities in this area concentrate on testing of components and conducting systems analyses of subsystems and operational procedures.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The $2 million diffenerce between the FY 1975 budget estimate from mission systems and integration and the current estimate stems from Congressional appropriation action reducing NASA's 1975 budget requested R&D appropriation.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In FY 1976 the Payload Integration and Mission Analysis program will emphasize studies and analyses involving definition of payload and operational requirements for use as design data for the Shuttle, IUS/Space Tug, and Spacelab; hardware and support svstems interface compatibility; low cost concepts for payload design and operations; new payload development approaches; new payload applications; the development of low cost, reusable multiuse mission support equipment to accommodate different payloads; and the formulation of procedures and systems for orbital and ground handling operations.

Funding in FY 1976 for Spacelab/Concept Verification Testing will provide for continued support of development and operations-oriented studies; design, fabrication and use of engineering mockups and will initiate development of peripheral flight hardware. Fiscal Year 1976 funds will also provide for acquisition of subsystems and associated computer software for concept verification testing of the Spacelab experiments.

Advanced Development funding in FY 1976 will provide for the development and test of new technology concepts, components and systems, and advanced operational software techniques for future program applications to reduce future program costs and technical risks; initiation of long-lead component and subsystem development. FY 1976 funds will also provide a basis for technical decisions through program planning and integration with the advanced missions studies, contractors, independent research and development efforts and other technology related activity.

The Interim Upper Stage/Space Tug FY 1976 funding will provide for defining NASA unique IUS requirements; performing systems analyses and preliminary subsystem development for the Space Tug; support USAF's evaluation and selection of an Interim Upper Stage (IUS); preparing a Tug Phase B Statement of Work; and supporting the Shuttle Critical Design Review (CDR).

The transition period funding will provide for continuation of the Payload Integration and Mission Analysis tasks; continuation of studies and the development of Spacelab support hardware and software; completion of the acquisition of the equipment and software for CVT, allowing the full system to be brought into operational capability in FY 1977; and continuation of the Advanced Development activities. Definition of NASA-unique IUS software and ground facilities requirements will be continued as well as initiation of a study to define crew training requirements.

Payload Integration and Mission Analysis

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$5,500	$5,500	$5,000	$6,000	$1,800

OBJECTIVES AND STATUS:

Objectives are (1) to assure hardware and operational compatibility between payloads and the Space Transportation System (STS), which incorporates the Space Shuttle, the Spacelab and the IUS/Space Tug, (2) to obtain the most effective utilization and economical operation of the STS; and (3) to provide low cost, standardized and reusable equipment to interface with the wide range of payloads to be transported, deployed and serviced by the STS.

To achieve these objectives, the following principal task areas have been identified; defining and projecting user payloads to determine the requirements imposed on payload/carrier vehicle interfaces and on the manner in which the STS accommodates the payloads; coordinating with users to incorporate new payload design and operations concepts; formulating procedures and systems for handling payloads both in orbit and on the ground; examining hardware design variations and scheduling combinations to achieve the most economical mission plans; and defining and developing multiuse mission support equipment for use with diverse payloads during all phases of STS operations.

51-423 O - 75 - 11

In FY 1975, STS planning activities have been focused on early Shuttle missions planning, and a preliminary plan has been developed. Payload operations and handling studies have helped to identify operations procedures, interfaces and hardware systems. Study effort is currently underway to identify STS/payload ground and flight interface/ancillary support hardware which would be more easily furnished from a standard inventory of equipment rather than by individual payloads.

This class of hardware has been identified as "multiuse mission support equipment." Initial identification of this equipment will be completed during FY 1975, leading to the preparation of an overall development plan defining equipment need dates, development lead times and funding requirements. During FY 1975, payload descriptions are being updated and refined. In addition, preliminary design reviews of the Space Shuttle have been conducted and are planned for the Spacelab and the launch and recovery facilities to analyze the compatibility of payload and STS interfaces. Planning activities for the first Spacelab mission were supported, and preliminary definitions of the first two years of Shuttle operations were developed. Contact is being maintained with the user community to determine new requirements for STS capabilities. The feasibility and cost effectiveness of various alternatives for orbital servicing of automated spacecraft are being studied. Analyses to development reimbursable policies and procudures for the Space Transportation System are being continued.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The current estimate reflects an adjustment made to accommodate Congressional appropriation action reducing NASA's FY 1975 budget request. As a result, the scope of effort has been reduced through across-the-board deferral of project content.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In FY 1976, study efforts will be concentrated on defining payload operations and handling procedures to support Shuttle missions. Effort will be devoted to formalizing the early Shuttle missions plan, developing agency mission models and conducting cost tradeoff analyses to support the planning efforts. New approaches for mission planning will be developed, mission planning computer capabilities expanded and payload cost estimation capabilities extended. In the multiuse mission support equipment area, FY 1976 activities will include conducting cost tradeoff analyses and starting definition and design of selected items. A portion of the FY 1976 effort will be used to analyze the compatibility of payloads and the STS launch and recovery facilities resulting from further detailing of payload requirements and proposed changes to the design and operation of the launch and recovery facilities. By the end of FY 1976, the Shuttle reimbursable policy will be defined

to a point where it will aid the early STS users in estimating their STS flight costs. Concepts for reducing the cost of space missions by servicing spacecraft in orbit will be refined, building on the operations and cost tradeoff studies performed during FY 1975. The FY 1976 effort will focus on the choice of a design approach for the various mechanisms and devices that comprise the servicing system and the development of plans and procedures for their use.

During the transition period, the following task areas will continue to be supported: (1) definition of payload processing and operational concept procedures, interfaces and hardware systems; (2) definition and design of selected multiuse mission support equipment; (3) studies to reduce the cost of space missions by servicing spacecraft in orbit; (4) refinement of STS mission model planning; and (5) definition of the reimbursable policy.

Spacelab/Concept Verification Testing

	1975			
	Budget	Current		Transition
1974	Estimate	Estimate	1976	Period
	(Thousands of Dollars)			
$2,500	$2,500	$2,000	$6,100	$1,900

OBJECTIVES AND STATUS:

The Spacelab will be a versatile payload carrier to be flown to and from space in the cargo bay of the Space Shuttle. Spacelab will allow researchers and scientists to conduct their experiments personally in a space environment, and, in some cases, to use their ground-based laboratory equipment in space to save additional cost. As part of the President's program of promoting greater international participation in the U.S. space effort, Spacelab is being designed and built for NASA by the European Space Research Organization (ESRO). Ten European nations (of which nine are members of ESRO) have agreed to fund Spacelab hardware development and to deliver flight hardware and associated ground support equipment and software to NASA.

Fiscal Year 1975 funds are being used to conduct studies at NASA's Marshall Space Flight Center in support of the European Spacelab development effort and NASA utilization plans. Studies include engineering cost trades, payload safety, payload accommodations, software development and payload operations. In addition, Spacelab funding is supporting simulated Spacelab missions using the Convair 990 aircraft to assess low cost payload integration and mission operations concepts. Fiscal Year 1975 funds are also being used to define the crew transfer tunnel to be used in conjunction with the ESRO-developed Spacelab, and to develop certain mockups and interface simulators.

Spacelab Concept Verification Testing (CVT) is a ground simulation activity supporting the planning for effective utilization and operation of the Spacelab. Through breadboards and simulators, CVT provides the means for development of effective interfaces, testing of experiment payloads, and conducting total systems simulations, including software, so that final flight experiment hardware can be designed for effective research and applications at low cost.

Fiscal Year 1975 funding is being used for completion of acquisition of the CVT Data Management Subsystem Simulator and development of associated support software. In addition, demonstration experiment activities and testing of commercial equipment for use in Spacelab are being carried out in FY 1975.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The current estimate reflects an adjustment to accommodate Congressional Appropriations action reducing NASA's FY 1975 budget request. The operational date of the CVT systems for Spacelab simulation will be delayed from June 1976 to March 1977.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Fiscal Year 1976 funding will be used to continue ongoing engineering studies in support of Spacelab development and to define new approaches to operating the Spacelab system with its variety of experimental payloads. Efficient and low-cost techniques for computerized approaches to experiment integration, mission planning, payload specialist training, and payload operations will be included. In addition, new studies will be initiated to determine the best logistics and ground operations procedures and to minimize on-board contamination which could be detrimental to the achievement of the scientific objectives of some experiments. Fiscal Year 1976 funds will also be used to initiate development of the crew transfer tunnel and procurement of a Spacelab high fidelity mockup.

In the FY 1976 transition period, funds will be used to continue engineering and logistics studies, and to continue the development of Spacelab support hardware and software. It is also expected that during this quarter the definition of the software and hardware necessary to operate the Spacelab with its planned payloads will be completed.

Fiscal Year 1976 funds will be used for simulation activities in the CVT Data Management Subsystem Simulator, and for partially equipping the CVT Spacelab Simulator and the CVT Shuttle Interface Simulator. Fiscal Year 1976 funding will also be used for testing key experiments in support of Spacelab operations development and for testing additional commercial equipment for Spacelab use.

The transition period funds will complete the acquisition of the equipment and software for CVT, allowing the full system to be brought into operational capability in FY 1977.

Advanced Development

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$7,500	$6,000	$5,500	$6,500	$2,000

OBJECTIVES AND STATUS:

The objectives of the Advanced Development program are to develop and test new technology concepts, components and systems, and advanced operational software techniques for future program applications to reduce program costs and technical risks; and to initiate critical long-lead component and subsystem developments.

Development activities are directed mainly toward future systems having multiple program application and a potential for high cost savings through increased reliability, longer life, and improved performance. Substantial savings or cost avoidance are achieved by early resolution of technical problems or substitution of alternative systems in critical areas before the program development phase.

Advanced Development tasks normally take from three to four years to complete since they involve the use of small numbers of high technology specialists who are pushing the state-of-the-art. In FY 1975, approximately 100 advanced development tasks are under contract to industrial firms, universities, research institutions, and other Government agencies. These tasks are for initiation or continuation of development activities on communication and information management systems; operations, maintenance, and safety requirements; advanced propulsion components; rendezvous and docking systems; new software systems; lightweight structures and materials; thermal control systems; space power systems; guidance and control hardware; and computer aided design capability.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The current estimate reflects an adjustment to accommodate Congressional Appropriation action reducing NASA's FY 1975 budget request. Since most of the available funding is committed to the continuation of efforts in progress, most of the new activities planned for FY 1975 have been deleted or deferred.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Fiscal Year 1976 efforts will continue the ongoing activities described and will be directed toward the following areas:

1. Tug related design criteria; definition of cost and performance effective subsystems; breadboard testing to demonstrate high risk technology areas; and testing of components for advanced liquid oxygen-liquid hydrogen and storable engine propulsion systems.

2. Long lead subsystem developments for use with the Space Transportation System, including improved on-board contamination evaluation and control techniques, thermal control of sensitive equipment and structures, and payload support subsystems.

3. Advanced computer software to handle the increased number and complexity of missions in the 1980's; software development work on high speed data base handling; computer aided mission planning and payload integration; simplified logistics support and automatic ground and flight checkout.

4. Technical requirements of future mission options, such as manned orbital systems, assembly of large structures in space and geosynchronous stations of the future.

Specific task activities will include:

Orbital Operations - Development and evaluation of the use of a laser radar for automatic rendezvous and docking; development of advanced laser gyro concepts; and development of a light weight highly reliable modular computer for long duration multi-use, Tug type upper stage guidance and control applications.

Thermal Control - Design of inflatable, deployable radiator systems to improve the Space Transportation System future mission capabilities; simplification of thermal control components for use by the Tug and other future, long-life, reusable spacecraft.

Propulsion and Power - Design and test of components to increase life and thereby reduce costs; initiation of testing of Shuttle fuel cell elements to determine their applicability to low power use associated with potential Tug application.

Communications and Information Systems - Development of S-band and Ku-band communication systems with emphasis on flush mounted electronically steerable antennas to eliminate large mechanically steered antennas; development of wide-band high data rate information processing systems to handle the large volume of data expected from Spacelab and IUS/Tug deployed payloads.

These activities will be continued during the transition period with particular emphasis on the design and testing of low cost, low power output fuel cells; light weight structures for stages that will handle high energy orbital placement, servicing, and retrieval of payloads; advanced liquid oxygen-liquid hydrogen engine components and improved radiator systems; inertial measuring unit incorporating laser gyros; electronically steerable antenna systems; rendezvous and docking systems; non-flammable materials; non-destructive testing techniques; data management systems and computer aided design.

Interim Upper Stage/Space Tug

	1975			
	Budget	Current		Transition
1974	Estimate	Estimate	1976	Period
	(Thousands of Dollars)			
---	$1,500	$1,000	$3,400	$700

OBJECTIVES AND STATUS:

The Space Shuttle upper stage is an integral part of the Space Transportation System. It is required to provide the capability to deploy Shuttle launched payloads to high-energy, and escape orbits not attainable by the Shuttle alone. The NASA and DoD have agreed on a two-phased upper stage development program. In the initial phase, the U.S. Air Force will develop the Interim Upper Stage (IUS), a modification of an existing expendable stage, in time to fly during the early Shuttle missions. It will be able to deploy, but not retrieve, payloads and may or may not be reusable, depending on the results of IUS definition studies which the U.S. Air Force currently has under contract. In the second phase, NASA will define and prepare for the development of a Space Tug, with increased performance, which will be fully reusable and will have the capability of deploying, retrieving and possibly servicing, on-orbit payloads. NASA's current efforts consist of defining NASA and other non-DoD requirements for input to the IUS system definition studies being conducted by the U.S. Air Force; conducting an engine verification program for the Space Tug; identifying the IUS NASA-unique hardware and software requirements for earth orbital missions and automated planetary missions; and defining the NASA ground systems interface.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The current estimate reflects an adjustment to accommodate Congressional Appropriations action reducing NASA's FY 1975 budget request. The initiation of Tug simulation and demonstration effort will be defered to FY 1976.

BASIS OF FY 19/6 AND TRANSITION PERIOD ESTIMATES:

NASA activity in FY 1976 will support the U.S. Air Force's evaluation of the current IUS system studies for the selection of a concept for the validation and development phases. Studies to define NASA-unique IUS/Tug software requirements will be based on the operations studies currently in progress. NASA ground facility requirements and operation plans for use of the IUS will be determined. For some outer planetary missions, additional propulsion units -- called auxiliary or "kick" stages -- may be necessary. Specific characteristics of NASA's automated planetary missions will be investigated to determine the requirements for auxiliary stages. Space Tug activities will concentrate on potential long-lead time problem areas identified in previous studies, such as spacecraft rendezvous and docking, interface attachments, engine two-position nozzle, and checkout procedures. These problem areas will be pursued in a simulation and demonstration program which will conduct candidate component testing and systems analyses of critical subsystems and operational procedures. Software and auxiliary stage studies for the IUS will also consider Tug requirements to insure an orderly transition from the IUS to the Tug.

In the transition period, definition of NASA-unique IUS software and ground facilities requirements will be continued and a study to define crew training requirements will be initiated. Preparations for the Tug Phase B effort will also be underway. Development of support documentation and verification of IUS and Tug Interfaces with the Shuttle Orbiter will commence in support of the Shuttle Critical Design Review.

Apollo Soyuz Test Project

	1974	1975 Budget Estimate	1975 Current Estimate	1974	Transition Period
		(Thousands of Dollars)			
Command and service module	$18,300	$8,000	$6,000	---	---
Docking module and docking system	16,000	3,400	4,400	---	---
Experiments	12,000	5,000	4,000	---	---
Launch vehicle	13,000	32,500	32,500	---	---
Launch operations	14,200	45,000	45,000	---	---
Flight support and operations	16,500	20,700	17,700	---	---
Total	$90,000	$114,600	$109,600	---	---

OBJECTIVES AND STATUS:

The Apollo Soyuz Test Project (ASTP) is a joint endeavor of the United States and the Soviet Union as part of the agreement on cooperation in space which the President signed in Moscow in May of 1972. Both countries have agreed to develop compatible rendezvous and docking systems and to test these systems in orbit with a joint experimental mission in mid-1975 to rendezvous and dock a manned Apollo spacecraft with a manned Soyuz-type spacecraft. These compatible rendezvous and docking systems will provide a basis for possible future joint manned space activity as well as space rescue. Each nation has separately developed docking systems based on a mutually agreeable single set of interface design specifications.

The major new U.S. program elements are a docking module and docking system necessary to achieve compatibility of rendezvous and docking systems with the USSR developed hardware on a Soyuz spacecraft. The docking module and system together with an Apollo command and service module (CSM) will be launched on a Saturn IB launch vehicle. The docking module and the docking system will be stowed in the spacecraft launch vehicle adapter and extracted by the CSM while in earth orbit in a manner similar to that used with the lunar module on an Apollo lunar mission.

The primary objective of the mission is to conduct space experiments to test the technical requirements and solutions for compatibility of systems for rendezvous and docking in orbit. More specifically, this includes the testing of a compatible rendezvous system in orbit, verifying techniques of crew transfers and inter-control center activities as well as testing of the universal docking assemblies. During both the docked and undocked phases of the mission, individual experiments covering the fields of earth resources, science, space processing and manufacturing, and life sciences will be conducted.

Joint US/USSR working groups have been meeting on a scheduled basis to review and agree on the technical and operational aspects of the joint project.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The FY 1975 Congressional Authorization for the Apollo Soyuz Test Project was $5 million below the budget request. It was necessary to rebalance the funding plans for the various ASTP project elements to absorb the Congressional reduction and to cover increased requirements for the docking module and docking system activities.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Fiscal Year 1976 new obligational authority is not required.

Command and Service Module

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$18,300	$8,000	$6,000	---	---

OBJECTIVES AND STATUS:

The Apollo spacecraft is a modified version of the command and service module (CSM) flown during the first several lunar landing missions. Major CSM modifications include additional propellant tanks for the reaction control system and the addition of controls and displays required for the proper operation of the docking module and docking system.

Fiscal Year 1975 funding provides for completion of modifications and checkout and for delivery of the flight spacecraft and launch vehicle adapters to the Kennedy Space Center; modification of the backup spacecraft; and development of compatible rendezvous and docked configuration guidance and navigation programs for the mission, including preflight checkout and verification.

Fiscal Year 1975 funding also provides for inplant engineering support for the flight spacecraft during the space vehicle assembly and checkout, the preparations for launch and the flight mission. Contract administration services provided by the Department of Defense on a reimbursable basis are also included.

Funding will also provide for support of the launch, flight, and mission operations in July of 1976. Post-flight activities in FY 1976 will include deactivation of the returned spacecraft and closeout of the spacecraft contracts, including disposition of property.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The current estimate for the command and service module effort reflects a $2 million downward adjustment as part of the actions necessary to absorb the $5 million Congressional authorization reduction in ASTP.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Fiscal Year 1976 new obligational authority is not required.

Docking Module and Docking System

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$16,000	$3,400	$4,400	---	---

OBJECTIVES AND STATUS:

The docking module is cylindrical in shape and is approximately 1.5 meters (about 5 feet) in diameter and 3 meters (about 10 feet) in length. It will serve as an airlock for the internal transfer of crewmen between the different atmospheres of the Apollo and Soyuz spacecraft. The docking module will be equipped with radio and TV communications, antennas, stored gases, heaters, and the displays and controls necessary for transfer operations.

The docking module is designed to handle two crewmen simultaneously. Hatches with controls on both sides will be installed at each end of the module. A universal docking system will be located at the Soyuz end of the module and will be capable of functioning with similar components on the Soyuz-type spacecraft.

Fiscal Year 1975 funding provides for final manufacturing checkout of the docking module test and flight articles; required ground testing; and engineering support involved in such activities as the docking module thermal vacuum qualification tests, the joint docking system qualification tests, and the US/USSR final joint docking system equipment acceptance review.

Fiscal Year 1975 funding also provides for development center engineering support for the flight docking module at the Kennedy Space Center during space vehicle assembly, final joint US/USSR docking system preflight compatibility tests of the flight hardware, and support of the docking hardware in preparation for launch, including the final flight readiness review and the flight mission.

Funding will also provide for support of the mission in July of 1975 and subsequent closeout of the docking module and docking system contract including disposition of property.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The current estimate reflects an increase of $1 million, which was transferred from experiments to cover additional requirements in the critical area of docking module and docking system development hardware.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Fiscal Year 1976 new obligational authority is not required.

Experiments

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$12,000	$5,000	$4,000	---	---

OBJECTIVES AND STATUS:

During the ASTP mission, important new experiments covering the fields of earth resources, science, space processing and manufacturing and life sciences will be conducted.

In the area of earth resources, experiments covering earth observations, doppler tracking, geodynamics and stratospheric aerosol measurements will be conducted.

In the field of scientific experiments, six experiments will be carried, covering extreme ultra-violet astronomy, helium glow measurements, ultra-violet absorption, sky-earth x-ray observations, artificial solar eclipse and crystal activation measurements.

Eleven space processing and manufacturing and six life sciences experiments are planned to be conducted. Eight of the space processing and manufacturing experiments involve the operation of a multipurpose furnace and include seven separate experimental samples which are to be processed in the furnace. Also included is the experimentation in electrophoresis processing, a process where an electric field will be used to separate living cells and other biological materials from a flowing medium without decreasing their activity, to determine whether the near zero gravity conditions enhance a similar process now involved in work by the Max Planck Institute in Germany on treatment of cancer by cell transfusions and transplants.

The life sciences experiments include extension of work done in the Apollo and Skylab programs, such as additional study of the phenomena of the cosmic light flashes observed by Apollo flight crews and studies of the effects of zero gravity and radiation on organisms. Studies will also be conducted on pre- and post-flight astronaut blood samples to determine, among other things, immunity retention. There are also joint US/USSR life science experiments planned, such as an experiment designed to determine

the degree of transfer of micro-organism and microflora between crew members and the two spacecraft involved in this mission. This experiment is designed to take advantage of a mission involving two spacecraft launched from widely separated ground environments.

Fiscal Year 1975 funding provides for the continued development, testing, qualification and integration of these experiments into the command and service module and the docking module. The funding also supports participation of the experiment principal and co-investigators in premission planning, crew training and flight readiness reviews. Requirements for data retrieval, reduction and analysis for one year after the mission are also included.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

Early development problems in experiment hardware required the application of more FY 1974 funds than anticipated. These problems were successfully solved in FY 1974, allowing the completion of the experiment program with $1 million less in FY 1975 funds than planned. This amount was reallocated to meet the Docking Module and Docking System requirements.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Fiscal Year 1976 new obligational authority is not required.

Launch Vehicle

	1975			
	Budget	Current		Transition
1974	Estimate	Estimate	1976	Period
	(Thousands of Dollars)			
$13,000	$32,500	$32,500	---	---

OBJECTIVES AND STATUS:

ASTP utilizes residual Apollo-Skylab Saturn IB launch vehicle hardware. The Saturn IB, consisting of an S-IB stage, an S-IVB stage, and an instrument unit, will launch the spacecraft from the Kennedy Space Center into earth orbit for rendezvous and docking with the Soyuz spacecraft.

Fiscal Year 1975 funding provides for launch vehicle stage sustaining engineering, and systems engineering and integration activities. The stage engineering capability will provide those engineering skills necessary to carry out contractor stage design responsibilities. These include continuing development of checkout criteria and requirements; checkout data

analysis and evaluation; required "make-it-work" changes, failure analysis, logistics management and other engineering activities required to support the final ASTP flight readiness review.

Systems engineering and integration activities include launch vehicle flight mechanics and trajectory studies for design and development of the launch vehicle flight program, flight and propulsion performance predictions and structural assessment of the stacked launch vehicle.

Funding will also provide for support of the launch in July 1975 and close-out of launch vehicle contracts, including disposition of property.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Fiscal Year 1976 new obligational authority is not required.

Launch Operations

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$14,200	$45,000	$45,000	---	---

OBJECTIVES AND STATUS:

Test and checkout operations of the U.S. space vehicle will be conducted at the Kennedy Space Center, with launch to be accomplished from Launch Complex 39B.

Fiscal Year 1975 funding will provide for the continuation of this contractor support, including final assembly of the space vehicle, movement of the vehicle to the launch pad, final checkout at the launch pad, and launch. Funds are also provided for fuels and pressurants to support the space vehicle checkout at the Kennedy Space Center, and the flight mission, and for the systems engineering effort to provide stage and command service module support necessary to meet all test, checkout and flight readiness activities required for the final readiness review and the launch. Funding will also provide for support of the launch in July 1975 and closeout of che launch support contracts, including disposition of property.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Fiscal Year 1976 new obligational authority is not required.

Flight Support and Operations

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$16,500	$20,700	$17,700	---	---

OBJECTIVES AND STATUS:

Flight support and operations provides for a broad range of essential activities which directly support the ASTP mission.

Fiscal Year 1975 funding covers continued maintenance of camera systems; food and waste systems; bioinstrumentation; and transportation. In addition, this funding provides for the continued procurement of Government-furnished equipment, including space suits, crew provisioning and television; communication and docking system tests and evaluations; and the use of automatic checkout equipment utilized previously on Apollo and Skylab.

Fiscal Year 1975 funding also provides for training of crew and flight controllers on ASTP equipment; maintenance of the docking module trainer; CSM fuels and pressurants to support test and checkout of the CSM and docking module; module and hardware transportation; cartography, and programmatic engineering support for the CSM, docking module, and docking system. In addition, FY 1975 funding also provides mission analysis and recovery planning; language translation capability, including interpreters; and a portion of the operations modifications to the mission control center in support of the mission.

Fiscal Year 1975 funds also provide for the cost of recovery of the crew and spacecraft; and the subsequent closeout of contracts, property disposition, transportation of the hardware returned from the mission and the preparation of final reports.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The decrease reflects a $3 million adjustment as part of the actions taken to accommodate the $5 million reduction in FY 1975 Congressional authorization.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Fiscal Year 1976 funds are not required.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

BUDGET SUMMARY

OFFICE OF MANNED SPACE FLIGHT — ADVANCED MISSIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Advanced mission studies....	$1,500	$1,500	$1,500	$1,500	$500
Total.....	$1,500	$1,500	$1,500	$1,500	$500
Distribution of Program Amount by Installation:					
Johnson Space Center.....	$576	$500	$450	$600	$200
Kennedy Space Center.....	130	200	150	150	50
Marshall Space Flight Center	575	600	500	600	200
Ames Research Center.....	12	---	---	---	---
Headquarters.....	207	200	400	150	50
Total.....	$1,500	$1,500	$1,500	$1,500	$500

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

OFFICE OF MANNED SPACE FLIGHT — ADVANCED MISSIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION

The objective of the Advanced Missions program is to conduct study efforts that examine the future direction of the nation's manned space flight program. New space systems, new operational concepts and advanced uses of existing systems evolve from these studies. Emphasis is given to the utilization of existing systems that can be used to advance the nation's space capabilities at a minimum cost. The Advanced Missions program also includes independent studies of potential new systems and operational concepts.

BASIS OF FUND REQUIREMENTS

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Advanced mission studies...	$1,500	$1,500	$1,500	$1,500	$500

OBJECTIVES AND STATUS

The advanced mission studies are the building blocks for new manned space flight programs. The Skylab, Apollo Soyuz Test Project and the Shuttle were originated and carried through Phase A level studies as a part of the advanced mission studies program. During FY 1971 through FY 1973, the advanced missions studies were devoted almost exclusively to the Space Shuttle and the Space Tug concepts. These programs are now an integral part of the Space Transportation System. With the FY 1974 program, a transition from Space Transportation System studies to exploration of new mission options was initiated.

The FY 1975 study program is examining the requirements for extensions and improvements of the Space Transportation System, and pursuing prior year studies of manned orbital systems concepts and related ground support and flight requirements. The effort to improve cost estimating techniques is continuing by the use of contracted studies to develop new procedures and to expand the data base. Independent studies are being conducted to assess the safety aspects of new systems and operational concepts. Integrated launch site operations for all elements of the Space Transportation System are also being studied.

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BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

The FY 1976 study program will include the exploration of new techniques for geosynchronous and low earth orbit applications with emphasis continuing on studies of manned orbital systems concepts, and on-orbit maintenance and assembly of large free-flying structures, such as solar power arrays, large radio telescopes and mirrors, and antennas. The feasibility of adding a crew module to the Tug for geosynchronous operations will be studied as well as initiation of a study of shuttle hardware utilization and growth options for advanced mission concepts.

During FY 1976, study efforts will also include evaluation of concepts evolving from NASA's long-range planning studies. An integrated approach to launch site operations will also be reviewed to identify problems and solutions associated with processing diverse kinds of modules and payloads.

During the transition period, payloads and launch site analyses will be continued so that an optimum set of capability and operational requirements can be constructed. Studies of orbital maintenance, module integration, and geosynchronous operation will also be continued.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1976 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR

SPACE SCIENCE PROGRAMS

Programs	Budget Plan				
		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)				
Physics and Astronomy.....	$94,000	$140,515	$136,315	$155,800	$46,600
Lunar and Planetary Exploration.....	392,482	266,000	266,000	259,900	73,300
Launch Vehicle Procurement.	178,000	140,500	140,500	166,900	40,400
Total.....	$664,482	$547,015	$542,815	$582,600	$160,300

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE — PHYSICS AND ASTRONOMY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(In Thousands of Dollars)			
Large observatories	$19,939	$50,410	$50,770	$62,000	$13,500
Orbiting explorers.	32,787	33,000	33,000	33,000	11,000
Suborbital programs	23,113	25,000	24,500	24,800	7,500
Supporting activities	17,661	28,605	24,715	31,400	11,100
Spacelab science program.....	500	3,500	3,330	4,600	3,500
Total.....	$94,000	$140,515	$136,315	$155,800	$46,600
Distribution of Program Amount by Installation					
Johnson Space Center.....	$180	$975	$850	$1,000	$200
Marshall Space Flight Center....	8,927	50,280	49,505	71,400	20,550
Goddard Space Flight Center....	56,755	55,875	55,419	53,038	17,075
Jet Propulsion Laboratory.....	650	650	628	700	400
Wallops Flight Center.....	2,150	2,850	2,404	2,800	800
Ames Research Center	6,435	6,905	6,927	7,400	1,950
Langley Research Center.....	2,708	1,705	1,358	862	925
Headquarters.....	16,195	21,275	19,224	18,600	4,700
Total.....	$94,000	$140,515	$136,315	$155,800	$46,600

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

OFFICE OF SPACE SCIENCE — PHYSICS AND ASTRONOMY PROGRAM

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Large Observatories:		
Solar Observatories	OSO-I	1975
High Energy Astronomy Observatories	HEAO-A	1977
	-B	1978
	-C	1979
Explorers:		
Space Physics Explorers	Dual Air Density	1975
	Atmosphere Explorer-D	1975
	-E	1975
	International Sun-Earth Explorer-A	1977
	-B	1977
	-C	1978
Astronomy and Astrophysics Explorers	Small Astronomy Satellite-C	1975
	International Ultraviolet Explorer	1976
Suborbital Programs:		
Sounding Rockets	About 65 launches per year	
Balloon Flights	About 40-50 launches per year	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

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 Earth's space environment, the sun, stars, and other celestial bodies. Under this program, research is being conducted to investigate the Earth's upper atmosphere and ionosphere, the magnetosphere, and the interplanetary medium. 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. These investigations 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 to small Explorer spacecraft, large automated observatories, and manned spacecraft. Research teams involved in this program are located at NASA field centers, other Government laboratories, universities, and industrial laboratories. Foreign participation is encouraged with the participating country providing its share of the costs.

The information obtained and the technology developed in the program are made available to the scientific and technical community for applications and advancement of scientific research, education, and technology. Major advances in special purpose microelectronic devices and photoelectric sensors have been made under this program since 1965; these have significantly enhanced the cost effectiveness of spacecraft and have found broad-based applications outside the space program.

The Physics and Astronomy missions undertaken to date have been highly successful and include the relatively low cost Explorer series of satellites commencing in 1959, which have made a number of very basic discoveries including the discovery of the Earth's radiation belts. The Observatories include the Orbiting Solar Observatory (OSO) series, and the High Energy Astronomy Observatories (HEAO) to be launched in 1977-79. The Apollo Telescope Mount (ATM), launched on Skylab in 1973, was the first of a new "second generation" of space observatories, where the skill of an on-board manned observer enhanced the capability of the largest observatory yet placed in orbit. During 1974, there were four missions, all successful: Hawkeye, a Magnetospheric Physics Explorer launched in June, and three

international cooperative astronomy Explorer-class spacecraft San Marco C-2 (Italy) launched in February--the Netherlands Astronomical Satellite (ANS) launched in August, and United Kingdom 5 (UK 5) launched in October.

The year 1975 will be a particularly active one with five launches scheduled. The OSO-I represents a considerable advance over its predecessors, by a factor of 900 in resolvable field of view and a factor of 100 in spectral resolution, which should greatly expand our knowledge of the Sun. The third Small Astronomy Satellite (SAS-C) will expand on the discoveries and observations of SAS-A (UHURU). Two Atmosphere Explorer missions (AE-D and E) will investigate the detailed processes which occur as a result of solar energy absorption in the lower regions of the Earth's atmosphere. The Dual Air Density (DAD) Explorer will investigate the uppermost layers of the Earth's atmosphere.

Work is continuing on the HEAO series designed to explore the previously inaccessible regions of celestial X-ray, gamma ray, and cosmic ray sources. These investigations will be carried out with three launches of HEAO in 1977, 1978, and 1979. Advanced technological development and mission planning have commenced on a Solar Maximum Mission (SMM) to take advantage of the next peak of the solar cycle. Work is also underway on Physics and Astronomy projects designed to capitalize on the capabilities of the Space Shuttle. Initial definition studies are underway to define a variety of Astronomy and Space physics payloads for the Shuttle. One of these Atmospheres, Magnetospheres, and Plasmas-in-Space (AMPS), would provide a large "laboratory in space" to conduct experiments utilizing the large volume and weight-carrying capabilities of the Shuttle. Advanced technological development is underway for a Shuttle-launched Large Space Telescope (LST), a multiple purpose telescope between two and three meters in diameter which will be able to observe galaxies at distances up to ten times farther than those which can be observed from the best ground-based observatory.

The funding requested for FY 1976 and the transition period provides for continuation of the on-going program.

BASIS OF FUND REQUIREMENTS

Large Observatories - Summary

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(In Thousands of Dollars)			
Orbiting solar observatories....	$12,763	$7,630	$5,400	$2,600	$500
Orbiting astronomical observatories....	2,326	2,380	2,470	2,800	1,000

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(In Thousands of Dollars)			
High energy astronomy observatories....	4,850	40,400	42,900	56,600	12,000
Total, Large observatories....	$19,939	$50,410	$50,770	$62,000	$13,500
(Launch vehicle procurement)					
Delta (OSO).....	($3,500)	(---)	(300)	(---)	(---)
Atlas/Centaur (HEAO).....	(---)	($8,900)	($7,000)	($19,500)	($5,100)
Orbiting Solar Observatories (OSO)					
OSO spacecraft.....	$8,689	$4,687	$2,308	$1,154	---
OSO experiments....	4,074	2,943	3,092	1,446	$500
Total, OSO.....	$12,763	$7,630	$5,400	$2,600	$500

OBJECTIVES AND STATUS

The Sun plays a dominant role in the creation and maintenance of an environment necessary to sustain life on Earth. The objective of the OSO program is to increase our understanding of the basic physical processes of the Sun and of their interaction with the Earth's environment.

The OSO series of missions has provided for a systematic study of the Sun both in terms of its cyclic variations and of a more directed study of spacific phenomena in response to the knowledge gained on previous missions.

The OSO's have provided significant discoveries about the Sun and the Earth, and have provided a foundation for design of the ATM flown on Skylab and for the Solar Maximum Mission proposed for the late 1970's. OSO-7, launched in 1971, took data on the solar corona and the spectrum of solar and cosmic X-rays until operations were terminated in June 1974.

OSO-I, to be launched in 1975 near solar minimum, will attack the puzzle of the very large temperature difference between the outer atmosphere of the Sun (one million degrees) and the lower atmosphere (ten thousand degrees). OSO-I will provide a substantial increase in spacecraft capabilities over previous solar missions, i.e., by a factor of 900 in resolvable field of view and a factor of 100 in spectral resolution. A comprehensive Guest Investigator Program has been initiated for OSO-I with about 50 investigators from six countries including the USSR.

Fiscal Year 1975 funds are being used for analysis of data from the OSO-7 mission and for the completion, launch, and mission operation of OSO-I.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The reduction in the FY 1975 estimate for OSO reflects a rephasing of requirements; an increase was required in FY 1974, with a corresponding decrease in FY 1975, to maintain assembly and test schedules leading to the planned launch of OSO-I in 1975.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Fiscal Year 1976 and transition period funds are required for support of the orbital operations of OSO-I, and for the reduction and analysis of the scientific data returned from the experiments.

Orbiting Astronomical Observatories (OAO)

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Program
		(Thousands of Dollars)			
OAO orbital operations, Data analysis....	$2,326	$2,380	$2,470	$2,800	$1,000

OBJECTIVES AND STATUS

Since 1968, the OAO program has provided astronomers with accurately stabilized, automated spacecraft observatories for telescopic observations of celestial objects primarily in the ultraviolet region of the electromagnetic spectrum. The last of this series of observatories, OAO-3 (Copernicus), was launched in August 1972.

One of several totally unexpected results of these missions was the discovery of a high temperature component of the interstellar gas whose temperature is in the vicinity of one million degrees. This component may occupy up to 90 percent of interstellar space. The discovery will have a significant impact on the theory of star formation from interstellar clouds.

Fiscal Year 1975 funds are being used for completion of the OAO-2 data analysis and for the operation and analysis of data obtained from the OAO-3. We are also supporting a Guest Observer Program which enables a broad segment of the astronomical community to use OAO to study celestial objects.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The FY 1975 funding has been increased to provide additional support for the Guest Investigator Program.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATE

Fiscal Year 1976 and transition period funds will be required for OAO-3 in-orbit operations and to provide for data processing and analysis of data obtained by the Princeton experiment. Support to the Guest Observer Program will be continued.

High Energy Astronomy Observatories (HEAO)

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(In Thousands of Dollars)			
HEAO spacecraft....	---	$22,024	$23,497	$34,009	$7,000
HEAO experiments...	---	18,376	19,403	22,591	5,000
Redefinition of HEAO program.....	$4,850	---	---	---	---
Total, HEAO.....	$4,850	$40,400	$42,900	$56,600	$12,000

OBJECTIVES AND STATUS

According to the best current theories, nearly one-third of the observable energy existing in the universe is in that portion of the spectrum which contains X-rays, gamma rays, and cosmic rays. The basic scientific objective of the HEAO program is to explore these regions of the universe which cannot be observed from the ground. This program has the potential to enhance our understanding of newly discovered energy processes and of the creation of matter, and thus lead to practical applications of these processes.

Also, it will greatly improve our understanding of observed phenomena such as quasars, pulsars, novae, and supernovae. Various advisory boards, including the President's Scientific Advisory Council and the National Academy of Sciences (Woods Hole Summer Study), have given this program a very high priority.

The program consists of two segments or "Blocks". Block I consists of three satellites, currently under development, to be launched on Atlas/Centaur rockets from the Eastern Test Range (ETR). Block II will be considered as a future new start to be launched by the Space Shuttle and will carry those heavier and larger types of instruments which Block I cannot accommodate.

About 80 percent of the HEAO subsystem components use existing flight hardware designs from ongoing programs such as OSO, ATM, SAS, and Fleet Satellite Communications (FLTSATCOM). The first launch in 1977, HEAO-A, will be an X-ray survey mission. The second mission, HEAO-B, will carry a grazing incidence X-ray telescope and will make detailed studies of specific sources indentified by HEAO-A. The third, HEAO-C, will carry a combination of gamma ray and cosmic ray instruments.

The FY 1975 funds provide for the detailed design and start of development of the spacecraft and the HEAO-A scientific instruments. Design of the HEAO-B instruments and mirror has also begun and definition of the HEAO-C payload is continuing. Long lead time items, such as telescope mirror blanks, large sodium iodide crystals, star sensors, and tape recorders are being procured. Subcontracts for vendor items have been negotiated and procurements are under way.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The FY 1975 requirements have increased by $2.5 million because of longer lead times for procurement of critical parts and higher labor rates than previously estimated.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATE

The FY 1976 and transition period funds are required to complete the fabrication of the HEAO-A experiments and spacecraft. Subsystems testing will take place and the overall systems vertification will begin after integration of the observatory. Design of the HEAO-B observatory will be completed and fabrication will begin. The grazing incidence telescope mirrors will be polished. The HEAO-C design effort will be completed during FY 1976. Mission operation efforts will include preparation of software as well as preparation of the mission control center.

Orbiting Explorers - Summary

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(In Thousands of Dollars)			
Space physics explorers.....	$19,283	$18,420	$18,289	$22,547	$6,600
Astronomy and astrophysics explorers.....	13,504	14,580	14,711	10,453	4,400
Total Explorers..	$32,787	$33,000	$33,000	$33,000	$11,000
(Launch vehicle procurement)					
Delta.....	($6,800)	($6,200)	($9,500)	($5,800)	($1,000)
Scout.....	(---)	(4,450)	(2,800)	(1,000)	(500)

The Explorer program provides the capability to conduct relatively low cost quick response investigations from Earth orbit. As the name implies, these satellites are exploratory in nature and have made a number of basic contrubutions beginning with the discovery of the Earth's radiation belts.

The Explorer satellites normally focus on a specific problem or discipline area. Problems in X-ray, gamma ray and radio astronomy, atmospheric and

ionospheric physics, radiation belts, magnetospheric boundaries, and interplanetary space are being investigated in this way. This program also provides a means for cooperative missions with other government agencies and other countries, where mutual program objectives can be met with the cooperating party paying its own costs.

Explorer spacecraft have been launched at a rate of about two to four missions per year, using both Delta and Scout launch vehicles.

Space Physics Explorers

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(In Thousands of Dollars)			
Atmosphere explorers (AE)...	$12,711	$7,480	$7,480	$5,500	$1,200
International Sun-Earth explorers (ISEE).....	---	6,800	6,957	15,000	4,000
Other space physics explorers.....	6,572	4,140	3,852	2,047	1,400
Total.....	$19,283	$18,420	$18,289	$22,547	$6,600

OBJECTIVES AND STATUS

These Explorers provide the means for conducting studies of the Earth's near-space environment. The program requires a wide variety of satellites extending from the very lowest reaches of the upper atmosphere, being investigated by the Atmosphere Explorers, to the interplanetary medium beyond the Earth's magnetosphere, being investigated by the Interplanetary Monitoring Platform (IMP) series.

The program is in a transition between the early discovery and mapping phase conducted over the past decade to a phase in which the cause and effects of the solar wind on the Earth's environment will be studied by means of simultaneous measurements at different locations by projects such as the International Sun-Earth Explorers (ISEE).

The year 1974 was very successful and included the launch in February of a satellite with Italy (San Marco C-2), as well as a Neutral Point Explorer mission (Hawkeye) which was successfully launched in June 1974. In 1975, it is planned to launch the Dual Air Density (DAD) Explorer.

The Atmosphere Explorers (AE) series consists of three missions. The first (AE-C) was successfully launched in December 1973. The second and

third, AE-D and E, will be launched during 1975. Each spacecraft is equipped with an onboard propulsion system which will permit the AE's to dip lower into the Earth's atmosphere than any previous satellite. This region has previously been investigated only by sounding rockets and is an area of increasing concern relative to the stability of the Earth's environment. Data from AE-C have demonstrated that large scale dynamic motions have an important direct bearing on the distribution of pollutants.

During 1974 we initiated a cooperative program with the European Space Research Organization (ESRO), which has been designated the International Sun-Earth Explorer (ISEE). This program consists of two launches in 1977 and 1978, involving three spacecraft which will usher in a new phase of investigation, that of real time cause and effect relationships between the incoming solar wind and its influence on the Earth's environment.

In response to two Announcements of Opportunities issued in the fall of 1974, a large number of proposals have been received from the scientific community for both experiments and complete Scout-class spacecraft. We have selected a number of candidate experiments for inclusion in conceptual studies of spacecraft to be conducted during 1975 under the Supporting Research and Technology program. These include the Electrodynamic Explorer designed to systematically investigate the Earth's electric field for the first time. A Mesospheric Explorer is also being considered to investigate this very critical region of the Earth's environment as it affects the transport of pollutants and the creation and stability of the ozone layer.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The reduction in the FY 1975 estimate reflects savings achieved through the launch of Hawkeye earlier than originally planned.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Fiscal Year 1976 and transition period funds are required for in-orbit operation of AE-C and D, analysis of data from AE-C and D experiments, and completion and launch of AE-E. In the ISEE project, funds will provide for procurement of hardware, subsystem fabrication, assembly, and test of the ISEE spacecraft. In addition, funds will be required for integration and launch of DAD, in-orbit operation of Hawkeye and analysis of data from Hawkeye experiments, the continued operation and reduction of data from the IMP-J and H launched in 1972 and 1973 respectively, the analysis of data from other missions previously launched, and definition studies of proposed missions.

Astronomy and Astrophysics Explorers

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(In Thousands of Dollars)			
Small astronomy satellites (SAS).	$6,500	$4,130	$4,230	$1,638	$500
International ultraviolet explorers (IUE)..	5,608	10,000	10,000	6,500	1,600
Other astronomy and astrophysics explorers.....	1,396	450	481	2,315	2,300
Total.....	$13,504	$14,580	$14,711	$10,453	$4,400

OBJECTIVES AND STATUS

These Explorers provide the means for carrying out astronomical studies relating to the sun, stars, galaxies, and planets which do not require large, complex astronomical observatories. Included here are the Small Astronomy Satellites (SAS); the Radio Astronomy Explorers (RAE); the International Ultraviolet Explorer (IUE), which is an international cooperative effort with the United Kingdom (UK) and ESRO; and cooperative astronomy missions with the UK and the Netherlands (UK-5 and ANS, respectively). The most recent mission, UK-5 and ANS, were successfully launched in October and August 1974, respectively. The SAS-C is scheduled for launch in the spring of 1975.

The Astronomy and Astrophysics Explorers permit the study of various spectral regions of the electromagnetic spectrum. SAS-A, launched in December 1970, was the first satellite devoted to X-ray astronomy and has raised X-ray astronomy to an importance equivalent to traditional optical astronomy. SAS-B, launched in 1972, was the first effective gamma ray satellite and has yielded the most comprehensive data on gamma ray distribution in our galaxy.

The IUE is designed to study, with high resolution, various processes occurring within and near the vicinity of many different ultraviolet emitting objects ranging from the planets to the puzzling quasars. This project has many unique features, including international agreements under which UK and ESRO will provide, respectively, the imaging system and the solar panels for a NASA spacecraft. This equipment, plus a planned ESRO ground station, represents a European commitment of more than $18 million to the IUE project.

As in the case of Space Physics Explorers, a number of proposed experiments have been identified as candidate payloads for inclusion in conceptual studies

of several proposed Explorers during 1975 under the Supporting Research and Technology Program. During FY 1976, it is planned to proceed with detailed design of the Energetic Gamma Ray Explorer Telescope (EGRET). This mission is planned for flight on an early Shuttle mission. The spacecraft will be a large step forward in the field of gamma ray astronomy, including the ability to study the structure of our galaxy with a high statistical accuracy and structural resolution. The definition phase of EGRET will be completed during FY 1975.

CHANGES FROM FY 1975 BUDGET ESTIMATES

The increase in the FY 1975 estimate reflects additional work required to remedy deficiencies disclosed during the final testing of the U.S. experiment on the ANS mission.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Fiscal Year 1976 and transition period funds will support the analysis of data from SAS-C experiments; the continuation of acquisition, processing, and analysis of data from operational satellites previously launched (SAS-A and B, RAE-B, ANS, and UK-5); the integration and test of the IUE preparatory to a mid-FY 1977 launch; the detailed design of EGRET; and the conduct of definition studies of proposed missions.

Suborbital Programs - Summary

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)				
Sounding rockets...	$18,113	$20,000	$19,600	$20,000	$6,200
Airborne research..	4,000	4,000	3,900	3,800	1,000
Balloon program....	1,000	1,000	1,000	1,000	300
Total, Suboribital Program.....	$23,113	$25,000	$24,500	$24,800	$7,500
(Launch vehicle procurement)					
Scout.....	(---)	($1,350)	($1,300)	(---)	(---)

Sounding Rockets

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$18,113	$20,000	$19,600	$20,000	$6,200

OBJECTIVES AND STATUS

The sounding rocket program provides a low cost and versatile 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 cosmic dust and interplanetary matter, magetospheric physics, stellar astronomy, solar astronomy, and high energy astrophysics. The current level of activity is approximately 65 rocket flights per year.

The specific objectives of the Sounding Rocket program are as follows:

1. To conduct a coordinated research program utilizing experiments with flight requirements which cannot be met by lesser performance vehicles and do not require long duration satellite observation. Specific areas of study include:

a. the nature, characteristics, and composition of the upper atmosphere, magnetosphere, and near space;

b. the effects of incoming energetic particles and solar and stellar radiation on the upper atmosphere and magnetosphere;

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 programs by providing the means for obtaining measurements at altitudes too low for satellites but too high for balloons or airplanes; 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 currently orbiting spacecraft.

3. To support personnel in space science experimentation, both on a domestic and an international cooperative basis at minimum expense.

In the magnetospheric physics area, continued emphasis has been placed on lower ionospheric measurements (low altitude measurements which can only be done with sounding rockets) and vertical scans correlated with Atmosphere Explorer measurements. Correlative measurements of auroral phenomena are also being made with ATS-6 satellite. Increasing emphasis is being placed on the coordination of near-simultaneous lauching of several rocket payloads. Fifty-four sounding rockets were launched during the summer of 1974 at Wallops Flight Center in a cooperative venture with the Air Force Cambridge Research Laboratory (AFCRL) called ALADDIN (Atmospheric Layering and Density Distribution of Ions and Neutrals). Luminescent clouds released by five rockets were observed from the NASA Lear Jets. A major activity during FY 1975 is an expedition to Peru for equatorial aeronomical observations.

In the stellar astronomy area, continuing emphasis is being placed on measurement of stars and extended sources in both the UV and X-ray regions.

Many observations will follow up the earlier measurements on satellites such as UHURU, OAO-A2, and OAO-3. Special types of instrumentation will continue to be flown in order to make measurements which cannot be made with existing satellites.

The Solar Physics Sounding Rocket program will continue to form an important part of the research in this area of Physics and Astronomy. After the intensive activity related to ATM calibration and collaborative investigations, the emphasis during FY 1975 will now shift to similar activities in support of the OSO-I mission. In addition, new instrumentation for studies of both quiet and active solar features is being developed and tested. Seven Solar Physics Sounding Rockets are planned for this period.

The Gravity Probe-A project, which was initated in FY 1972 to confirm with improved accuracy the gravitational redshift (relativistic frequency shift) predicted by Einstein's Theory of Relativity, has proceeded through the design stage, and hardware is now under development and test.

CHANGE FROM FY 1975 BUDGET ESTIMATE

The decrease in FY 1975 funding results from a postponement in the procurement of replacement vehicles.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

During FY 1976 and the transition period, there will be a continuation of most of the activities discribed above, with emphasis on the coordination of rocket launches and on correlation with satellite observations. Environmental test for the Gravity Probe-A will be completed, the flight performed, and data analysis initiated.

Airborne Research

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$4,000	$4,000	$3,900	$3,800	$1,000

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 extended observations over the entire Earth. It also may be transported readily to high operational altitudes, near 15 Kilometer (Km) (50,000 feet) in order to provide a cloud-free site for geophysics experiments and astronomical observations. The possibility of conducting experiments at this cloud-free

51-423 O - 75 - 13

altitude has been essential in opening to astronomy the infrared region of the electromagnetic spectrum from 10,000 Angstroms to one millimeter. The airborne platform has the further advantage of enabling scientists to participate directly in the space experiment.

Efforts have been concentrated in the infrared astronomy program, although geophysical investigations such as auroral studies and measurements of motions and fields in the upper atmosphere using photographs of chemicals released from rockets have been included.

The 91 centimeter (cm) IR telescope on the C-141A aircraft began operational flights in 1974. This Airborne Observatory is a full scale, manned facility. The 91-cm, f/13.5 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).

Infrared astronomers have actively participated in the Airborne Research program for over three years utilizing a 30-cm telescope carried on a Lear Jet. This Lear Jet program involves, at present, about ten astronomical groups.

The FY 1975 Airborne Research program funds have been used to complete the operational testing and initiate operations of the Airborne IR Observatory on the C-141A. The Lear Jet astronomical program continues to support infrared astronomy objectives.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The reduction in the level of funding was made possible by the purchase, in 1974, of a Lear Jet, which eliminated the need for budgeting lease costs formerly associated with the Lear Jet activity.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

The FY 1976 and transition period airborne research budget will be used mainly to continue operations of the Airborne Observatory. Requirements cover support for the astronomical groups, acquisition of subsystems, and operation of the C-141A. The Lear Jet program will also be continued.

Balloon Program

1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$1,000	$1,000	$1,000	$1,000	$300

OBJECTIVES AND STATUS

In the development of scientific experiments for space flight and other independent scientific missions, it is necessary to test the instrumentation in the space environment and to make observations at altitudes which are not accessible to rockets and spacecraft. In many instances, it is less expensive and more efficient to fly these payloads on balloons. The new "superpressure" balloons, in particular, offer unique opportunities for long duration missions. Approximately one million dollars has been expended annually to support about 40-50 balloon flights a year. These funds provide for balloons, helium and special services. Funding for the experiments is provided from Supporting Research and Technology (SR&T).

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

The FY 1976 and transition period request will support a level of effort approximately equal to FY 1975, although a decrease in total number of flights is possible due to the increased emphasis on more complex payloads, higher altitude requirements, and correspondingly larger balloons and, perhaps most important, the combined effects of inflation and higher costs of petroleum-based products such as balloons.

Supporting Activities

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(In Thousands of Dollars)			
Supporting research and technology (SR&T).....	$12,780	$14,390	$13,800	$14,400	$4,000
Data analysis.....	4,881	5,000	5,000	5,000	1,300
Skylab data analysis	---	1,500	1,400	6,000	1,500
Large space telescope (LST) - advanced technological development.....	---	6,200	3,000	5,000	3,000
Solar maximum mission (SMM) - advanced technological development.....	---	1,515	1,515	1,000	1,300
Total, Supporting Activities.....	$17,661	$28,605	$24,715	$31.400	$11,100

Supporting Research and Technology (SR&T)

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$12,780	$14,390	$13,800	$14,400	$4,000

OBJECTIVES AND STATUS

This effort enhances the overall scientific and technological return from NASA flight projects and helps assure the continued viability of the future research program in space science. The objectives can be stated in the following three broad categories: (1) enhancement of the value of current space missions by supplementary simultaneous ground-based observations; (2) development of theories to explain observed phenomena and predict new ones; and (3) optimization of the return expected from future missions by problem definition, development of advanced experiments and concepts, and careful definition of proposed new missions.

The work in space physics is largely devoted to support of research related to physics of the Earth's environment. It includes study of the Sun-Earth environment factors, as well as extrasolar factors such as cosmic rays. Research supported in the field of astronomy involves the study of the Sun and objects outside the solar system. Specific tasks include studies of the solar atmosphere and the influence of the Sun on interplanetray and planetary environments, work instrument development, and laboratory and theoretical studies of basic physical processes peculiar to the Sun. Also included are solar radio astronomy projects and research tasks related to objects outside of the solar system, including observation by ground-based and balloon-borne telescopes. Theoretical studies of stars, galaxies, interstellar and intergalactic matter, and advanced development work on experimental tests of the validity of Einstein's Theory of Relativity are also supported in this area.

About 225 tasks are being supported at universities, nonprofit and industrial research institutions, NASA centers, and other Government agencies in 26 states and the District of Columbia. These tasks include continuing studies of advanced missions and Advanced Technological Development (ATD) of solid state detector devices, superfluid helium research, development of improved photometers and support of theoretical investigations.

CHANGES FROM FY 1975 BUDGET ESTIMATES

SR&T funding in FY 1975 has been reduced slightly from the planned level by postponing certain ATD tasks, and mission planning activity, such as that for a follow-on Gravity Probe Mission.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

During FY 1976 and the transition period, continued support will be given to those tasks which are critical to maintaining a firm base for a viable Physics and Astronomy program. Of special significance is the continuation of studies for advanced instrumentation involving image tubes and solid state devices which will increase sensitivity and resolution of detectors. Superfluid helium research will be continued for cryogenic systems for future application in cosmic ray, relativity, and infrared astronomy. Other technological problems concerning pointing and stabilization, onboard processing, onboard data storage, and detector background will be studied. In addition, studies will be made of advanced techniques for releasing tracers into the upper atmosphere and of such instruments for introducing controlled perturbations into the space environment as spaceborne radio transmitters, electron and ion accelerators and lasers. Basic studies will be continued to define future scientific objectives in astronomy and physics that will utilize the capabilities of early shuttle missions.

Data Analysis

	1975			
	Budget	Current		Transition
1974	Estimate	Estimate	1976	Period
	(In Thousands of Dollars)			
$4,881	$5,000	$5,000	$5,000	$1,300

OBJECTIVES AND STATUS

The purpose of this effort is to obtain the maximum return on the investment represented by the data gathered in the Space Science program, including that from a number of spacecraft which are operating well beyond their planned lifetimes.

Limited operation of spacecraft, beyond the times originally planned, has made additional data available for specific investigations with preference being given to correlative operations designed to illuminate physical problems, and to the exploitation of unusual opportunities such as unexpected encounters with comets. Further work using existing data is also supported, with emphasis on correlative studies. Under this project, investigators are expected to prepare data, complete with calibrations, in a form suitable for deposit in the National Space Science Data Center.

The operation of the National Space Scinece Data Center is also supported under this project.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Fiscal Year 1976 and transition period funds will provide support for about 100 principal investigators at approximately 46 institutions, including NASA field centers.

Skylab Data Analysis

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
---	$1,500	$1,400	$6,000	$1,500

OBJECTIVES AND STATUS

The Skylab Data Analysis project will support the integration of data from ATM and other Skylab experiments, the ATM Guest Investigation Program, and symposia and workshops on ATM results.

The data acquired by the six major ATM instruments, together with that obtained by the worldwide program of complementary ground-based and rocket-borne observations from the most comprehensive set of simultaneous high resolution solar data ever collected. An analysis of these data promises to advance man's knowledge of the structure and dynamics of the solar atmosphere, and of the coupling between the solar atmosphere, the solar wind and the terrestrial atmosphere, far beyond its present state. Studies of transient events such as flares are proving particularly fruitful. Not only is there evidence of possible precursors to these events but, for the first time, the interaction between activity and solar wind structure can be studied. These results will prove invaluable in the design of future space efforts oriented specifically toward the understanding of flares.

The Skylab FY 1975 activities are primarily directed toward the reduction and cataloging of the vast quantity of photographic and photoelectric data obtained (over 171,000 photographic images from ATM alone). In addition, the preparation of atlases and high quality film copies for the National Space Science Data Center, the determination and application of instrument calibrations and the preparation of specialized computer software are important activities in this time frame. Preliminary analyses of the data obtained are also underway.

CHANGES FROM FY 1975 BUDGET ESTIMATES

The $100 thousand reduction in the FY 1975 estimate reflects a change in the scope of activities for ATM principal investigators and guest investigators.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Fiscal Year 1976 and the transition period will see the emphasis in the Skylab Data Analysis Program shift from the basic reduction and preparatory task to data analysis, and the primary support for these activities will shift from the Office of Manned Space Flight to the Office of Space Science. The quantity of data and the complexity of its processing will necessarily result in an extension of this phase over several years. However, the combined efforts of the Skylab scientists and their collaborators in the definition of many scientific objectives will help make this period one of the most productive and exciting ever known in solar physics.

Large Space Telescope (LST)-
Advanced Technological Development (ATD)

	1975			
	Budget	Currect		Transition
1974	Estimate	Estimate	1976	Period
	(In Thousands of Dollars)			
---	$6,200	$3,000	$5,000	$3,000

OBJECTIVES AND STATUS

The LST, is under study as a possible future project for a shuttle launched multiple purpose telescope, between two and three meters in diameter, to provide the capability for making unique major advances in astrophysics.

The LST will contribute significantly to the study of little-known energy processes in heavenly bodies, especially the early stages of star and solar system formation; 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. The LST will assist in the determination of whether or not our solar system is unique, whether there are other earth-like planets orbiting "suns" similar to ours and many other questions involving the nature and structure of the universe. Knowledge gained from the scientific investigations may well contribute to our continued pre-eminence as a high technology society.

In the priority study just completed by the Space Science Board of the National Academy of Sciences, the LST was considered to be the highest priority new program in astronomy and was recommended for implementation starting in FY 1976. Since the definition studies are not yet completed, NASA will not be in a position to start the hardware phase until FY 1977.

During the FY 1975 Congressional hearings, NASA was asked to look at lower cost options for the LST and to investigate the possibility of international participation. In response to this request, the contractors which have been studying the Optical Telescope Assembly/Scientific Implementation have been directed to investigate and to recommend methods of reducing the total cost of the LST project.

In November 1974, three aerospace companies-- Boeing Aerospace Company, Lockheed Missiles and Space Company, Inc., and Martin-Marietta Corporation-- were selected to provide the definition studies necessary for a more detailed definition of the Support Systems Module, the spacecraft portion of the telescope, previously studied in-house by the Marshall Space Flight Center. These three companies will examine LST primary optics ranging in size from 1.8 meters (5.91 feet) to 3 meters (9.85 feet).

Initial results from our in-house trade-off studies indicate that a telescope in the middle of this range appears to represent an appropriate compromise between performance and cost. The optical technology is well in hand and no new facilities are required to handle the primary mirror. The smaller overall spacecraft and the relaxation in performance means that lower cost subsystems can be used. While a smaller mirror would mean some reduction in performance, an intermediate system on the order of 2.4 meters (7.9 feet) would clearly represent a significant advance over any existing or planned space telescope.

For the past two years, a team of approximately thirty astronomers has worked with NASA to determine the requirements for the scientific instrumentation to be used in conjunction with the LST. One of the ways to approach a lower cost LST is to reduce the number of instruments. To help us examine this option the instrument definition teams have established a priority list of candidate instruments which could accomplish the scientific objectives outlined for the LST project. This list includes such instruments as the High Resolution Camera (f/24) and the Faint Object Spectograph.

As a part of the NASA response to the desires of the Congress for lower cost options, ESRO and individual European countries were contacted to explore the possibility of their contributing parts of the LST . Pratical areas identified for their participation were the scientific instruments and solar panels. Definition studies are underway at both ESRO and the United Kingdom for scientific instruments they could contribute.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The FY 1975 Budget Estimate has been reduced by $3.2 million in accordance with Congressional direction. This reduction resulted in the deferral of an instrumentation technology task, primary and secondary mirror studies, and several ATD tasks such as fine pointing controls, thermal controls, and analytical studies of the telescope assembly.

BASIS FOR FY 1976 AND TRANSITION PERIOD EXTIMATES

During FY 1976 and the transition period, NASA will concentrate on a specific size and preliminary design for the LST. Careful planning and cost estimating will be performed to insure that the LST can be developed, built and put into operation within the resources and the time schedule projected. Long-term

development such as the sensors and selected ATD will be continued to avoid costly problems later. All of the imformation necessary to provide a sound technical and financial basis on which to proceed with the implementation phase of the program will be available by the end of this period.

Solar Maximum Mission (SMM)-
Advanced Technological Development (ATD)

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
---	$1,515	$1,515	$1,000	$1,300

OBJECTIVES AND STATUS

The Solar Maximum Mission (SMM) is planned to conduct specific problem-oriented solar scientific research during the next period of maximum solar activity, projected to occur at the end of this decade. The major scientific objectives of SMM will be to investigate solar flares and related phenomena over a broad spectral range with high time, spectral and spatial resolution.

The solar flares are perhaps the most dramatic and elusive of the observable solar phenomena. They have a profound impact on the solar-terrestrial system, but are difficult to study because they are transient in nature.

The SMM will provide the capability to make simultaneous measurements across the electromagnetic spectrum for the first time. The information to be developed will provide the potential for forecasting flares and their effects on Earth.

The SMM will play a pivotal role in a coordinated national program of satellite, sounding rocket, and ground-based observations of flares and their effects and is the most important solar mission proposed for this decade. The SMM will provide opportunities for international cooperation on the basis of mutual interest and benefit.

Mission definition studies were initiated in the spring of 1973. In 1974 we completed the conceptual design studies of the supporting spacecraft systems and associated ground operations facilities. The design concept provides for a spacecraft which capitalizes on common components and standardized subsystems to achieve a lower cost spacecraft system capable of meeting the required pointing accuracies for this mission. The spacecraft will be shuttle-compatible, capable of rendezvous, retrieval, refurbishment, and return to orbit.

A preliminary science payload has been selected based on proposals from the solar physics community. This payload includes instruments for the

observation and study of nuclear reactions in flares through gamma-ray emission; the acceleration dynamics of charged particles to high (sometimes relativistic) energies through hard and soft X-rays; the temperature and density in flaring regions through soft X-rays and ultraviolet line emissions; and the ejection of material from the sun through X-rays. It is planned that the final selection of the scientific payload will be made in mid-1975.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

During Fiscal Year 1976 and the transition period, it is planned to complete definition and preliminary design studies of the scientific experiments and of the supporting spacecraft systems in preparation for the implementation phase of the program.

Spacelab Science Program

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(In Thousands of Dollars)			
Space science payload definition..	$500	$3,500	$3,330	$3,500	$900
Spacelab science payload development	---	---	---	1,100	2,600
Total, Spacelab Science Program	$500	$3,500	$3,330	$4,600	$3,500

The Shuttle-launched Spacelab will offer unique space flight opportunities to conduct Physics and Astronomy research with instrumentation and operations similar to those used in ground-based observatories. This program is building upon the experience and accomplishments of both previous and ongoing flight projects, including the extremely successful Skylab mission.

Spacelab Science Payload Definition

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$500	$3,500	$3,330	$3,500	$900

OBJECTIVES AND STATUS

To prepare for the opportunities for scientific investigations in the Shuttle era, Spacelab Science Payload studies are underway which will generate data on which to base priority decisions for initiatives and to

examine the extent to which costs may be reduced for payloads developed for Space Shuttle flight. Initial studies concern facility-class payloads that would be flown from one to several times per year and would have an operational life comparable to traditional ground-based facilities.

In Atmospheric and Space Physics, a preliminary payload design for the Atmospheres, Magnetospheres, and Plasmas-in-Space Spacelab (AMPS) is in progress. This facility will capitalize on the commonality of instrumentation required for investigations of the dynamics of the near-earth environment in the several disciplines represented. An AMPS Work Group is to provide scientific defintion of this facility.

In Astronomy, similar definition studies have begun for a meter-class, cryogenically cooled, infrared telescope facility; a meter-class, high resolution optical/ultraviolet telescope facility; and a solar physics telescope cluster facility. For each of these studies, a scientific working group has been formed to provide the study with scientific definition appropriate to the objectives of the facility. To capitalize on the economy of common usage in the astronomy fields, a study to define the systems and subsystems required for astronomy-type payloads is in progress.

CHANGES FROM FY 1975 BUDGET ESTIMATE

A reduction in the FY 1975 estimate reflects a change in the level of AMPS study activity planned for FY 1975.

BASIS OF FY 1976 AND TRANSITION PERIOD EXTIMATES

Fiscal Year 1976 and transition period funding will be used to complete the definition of the total AMPS Space Laboratory and related facility instrumentation; for definition of a complement of High Energy Astrophysical instruments for the second Spacelab; for preliminary definition and design of a national Infrared Astronomical Spacelab Observatory and a national Solar Physics Spacelab in accordance with recommendations by the National Academy of Sciences; and for the continuing study of the scientific objectives and specifications of a one-meter-class high-resolution ultraviolet telescope.

Spacelab Science Payload Development

	1975			
	Budget	Current		Transition
1974	Estimate	Estimate	1976	Period
	(In Thousnads of Dollars)			
---	---	---	$1,100	$2,600

OBJECTIVES AND STATUS

The first Spacelab flight, which will be a joint effort with the European Space Research Organization, will carry a multi-disciplinary payload. The specific instruments to be flown will be selected from those identified in the Spacelab Science Payload Definition activity which has been funded under the Physics and Astronomy Program since FY 1973.

While Astronomy, High Energy Astrophysics and Solar Physics are included as major program disicpline elements of the overall Spacelab Science Payload Development Program, the emphasis in the intial flight is on Atmospheric and Space Physics. Several prime candidate instruments are incremental building blocks of instruments currently planned for the Atmospheres, Magnetospheres and Plasmas-in-Space (AMPS) mission which is being studied for flight on a later Spacelab mission. The incremental development of these instruments, such as the Electron Accelerator, used for controlled excitation of ionospheric and magnetospheric phenomena, and a laser radar (LIDAR) system for excitation and observation of the neutral atmosphere, will be initiated during FY 1976. Selection of these instruments is consistant with the philosophy of providing for an early scientific return while building to the more comprehensive AMPS flight. This allows significant science to be accomplished with hardware which can then be further upgraded and used as part of more specialized payloads at considerable cost savings.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

The selection and development of scientific instruments for the first Spacelab mission will begin in FY 1976 and extend through the transition period. A flight readiness date of early FY 1980 is planned.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE — LUNAR AND PLANETARY EXPLORATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Mariner Venus/Mercury..	$11,135	$4,119	$5,377	---	---
Viking.....	290,437	89,016	89,016	$39,500	$14,000
Outer planets missions.	27,390	69,761	69,761	82,400	22,600
Pioneer/Helios.....	7,005	33,500	33,642	62,600	16,300
Supporting research and technology/advanced studies.....	11,195	14,300	14,300	14,300	3,600
Planetary astronomy....	3,800	4,200	4,200	4,200	1,100
Data analysis.....	1,400	1,400	1,400	1,400	400
Planetary quarantine...	1,500	1,500	1,500	1,500	400
Planetary flight support.....	21,170	25,500	24,900	29,300	8,800
Lunar research program.	17,450	22,704	21,904	24,700	6,100
Total.....	$392,482	$266,000	$266,000	$259,900	$73,300
Distribution of Program Amount by Installation:					
Kennedy Space Center...	---	---	$22	---	---
Johnson Space Center...	$8,102	$12,726	10,908	$10,884	$2,839
Marshall Space Flight Center.....	25	---	20	---	---
Goddard Space Flight Center.....	6,380	8,090	8,558	7,553	1,640
Jet Propulsion Laboratory.....	57,371	91,700	90,937	99,397	28,603
Wallops Flight Center..	55	50	55	55	25
Ames Research Center...	9,266	35,722	37,831	64,825	17,057
Langley Research Center	274,273	94,110	94,476	48,914	16,151
Headquarters.....	37,010	23,602	23,193	28,272	6,985
Total.....	$392,482	$266,000	$266,000	$259,900	$73,300

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

OFFICE OF SPACE SCIENCE

LUNAR AND PLANETARY EXPLORATION PROGRAM

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Pioneer/Helios	Helios A	1974
	Helios B	1976
	Pioneer Venus-Probe Mission	1978
	Pioneer Venus-Orbiter	1978
Viking	Mars 1975 (2)	1975
Outer Planets Missions	Jupiter-Saturn (2)	1977

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

OFFICE OF SPACE SCIENCE — LUNAR AND PLANETARY EXPLORATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Lunar and Planetary Exploration program is the scientific exploration of the moon, the planets and their satellites, asteroids, comets, and the particles and fields of interplanetary space. The goal of this exploration is to understand the origin and evolution of the solar system, the origin and evolution of life, and the dynamic processes that shape man's terrestrial environment. The planning program employs automated spacecraft which fly by, orbit, enter the atmosphere of, and/or land on other bodies, as well as ground-based observations to investigate our solar system. The lunar program utilizes ground-based observations, laboratory studies and data from the Apollo, Ranger, Lunar Orbiter, and Surveyor missions to investigate the composition and nature of lunar materials and phenomena.

The planetary and interplanetary flight missions undertaken to date have been highly successful, beginning with the first visit to another planet--the Mariner 2 flyby of Venus in 1962--and continuing with the first successful orbiting of Mars in November 1971 by the Mariner 9. Pioneer 10, launched in March 1972, has now successfully traversed the Asteroid Belt and survived the radiation belts of Jupiter. Pioneer 11, launched in April 1973, has now completed its mission to Jupiter and is at present on its way to Saturn. Both of these missions have provided valuable data on these first trips to Jupiter. Mariner 10, launched in November 1973, successfully gained scientific measurements of Venus and Mercury and was the first spacecraft to use an intermediate planet for the gravity assist required to reach its ultimate objective. Two cooperative US/German spacecraft, Helios A, launched in 1974, and Helios B, to be launched in 1976, will investigate the properties in interplanetary space in close proximity to the sun. Knowledge of Mars and its environment, including the possibility of life there, will be greatly advanced by the two Viking spacecraft, to be launched in 1975, which will orbit and land on the Martian surface in 1976. In 1977, two Mariner spacecraft will be launched to fly by Jupiter and Saturn and their satellites, thereby extending man's frontier of knowledge about the solar system farther into the outer planets. The heavy veil of the planet Venus will be penetrated by instruments carried on two Pioneer spacecraft scheduled to be launched in 1978. The probe and orbiter missions will investigate the nature, dynamics and evolution of the Venusian atmosphere and will provide useful data to Earth meteorologists.

BASIS OF FUND REQUIREMENTS:

Mariner Venus/Mercury 1973

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Spacecraft	$5,265	$1,332	$1,332	---	---
Science	2,303	2,134	2,134	---	---
Mission operations	3,567	653	653	---	---
Third encounter support	---	---	1,258	---	---
Total	$11,135	$4,119	$5,377	---	---

OBJECTIVES AND STATUS:

This single Mariner spacecraft was successfully launched in November 1973. It has now successfully completed its swingby of Venus and two encounters with Mercury. The science data gathered to date by this mission has provided valuable insight into the circulation patterns of the upper Venusian atmosphere, yielded important experience in gravity assisted, multiplanet trajectories, and revealed the moon-like topography of Mercury.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

Following the successful completion of the basic Mariner Venus/Mercury (MVM) objectives, analysis indicated that through judicious gas management and utilization of "solar sailing" techniques, spacecraft stabilization could be maintained and enough gas made available for a further trajectory correction. With this small maneuver a third Mercury encounter became possible. The trajectory correction was successfully accomplished, and funds were applied to continue science and mission operations support through the third encounter in March 1975.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

No additional funds are required to complete this mission.

Viking

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Orbiter spacecraft..	$55,450	$26,000	$26,000	$9,200	$7,000
Orbiter science.....	8,320	4,000	4,000	2,100	1,200
Lander spacecraft...	142,892	27,008	27,008	17,700	400
Lander science.....	69,500	14,808	14,808	4,600	1,900
Project management and project integration.....	14,275	17,200	17,200	5,900	3,500
Total.....	$290,437	$89,016	$89,016	$39,500	$14,000
Titan/Centaur (Launch Vehicle Procurement Program).....	($23,000)	($2,400)	($2,400)	($300)	(---)

OBJECTIVES AND STATUS:

The objective of the Viking program is to significantly advance our knowledge of the planet Mars by means of observations from Martian orbit and direct measurements in the atmosphere and on the surface. The Viking 1975 mission will greatly expand the exploration of Mars initiated by the earlier Mariners. Emphasis will be placed on obtaining biological, chemical, and environmental data relevant to questions about the existence of life on the planet.

Two Viking spacecraft will be launched in mid-1975 by Titan/Centaur launch vehicles. Each spacecraft will consist of an Orbiter and a Lander. When the spacecraft arrive at Mars in the summer of 1976, each Orbiter will place itself and the attached Lander into an orbit around Mars. Each Lander will separate from its Orbiter shortly after arrival at Mars and descend through the atmosphere to the surface. After soft landing, the Lander will take panoramic color pictures and will conduct biological, geo-chemical, seismological, meteorological, and other scientific investigations. Instruments on the Orbiters will obtain data on dynamic planetary processes, view the surface in high resolution, and act as communications relay stations for both Orbiter and Lander scientific data.

During FY 1975, funds are being used to complete the qualification testing of the Lander; to complete the assembly and testing of two flight Orbiters and two flight Landers; and to proceed with software development, training, and the spacecraft final preparations necessary for two launches in the first quarter of FY 1976.

RD 5-6

CHANGES FROM FY 1975 BUDGET ESTIMATE:

Although there was no change in the use of funds appropriated for the Viking project in FY 1975, funding to support FY 1975 activities was made available through reprogramming funds appropriated pursuant to the 1974 Authorization Act. The Congress was apprised of this action in October 1974. The reprogrammed funds were required to solve the technical problems encountered in the guidance computer, biology instrument, and the proof test Lander capsule qualification program.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In June 1975, four spacecraft (two Landers and two Orbiters) will be in final assembly and test operations at the Kennedy Space Center. Then, in July 1975, at the start of FY 1976, the two Landers will be sterilized by heat in large ovens. Afterwards, the Landers and Orbiters will be mated and then each combined spacecraft will be encapsulated, transported to Launch Complex 41, and installed on its Titan IIIE/Centaur launch vehicle.

The launch period begins on August 11, 1975, and extends for roughly 40 days. During this period, both the Viking A and B spacecraft will be launched from the single pad to begin the flight operations portion of the mission to Mars.

After launch, the mission will be directed by the flight team from the Space Flight Operations Facility (SFOF) at JPL. One part of the flight team will be involved in writing and testing software for the planetary phase of the flight. Another part of the flight team will be monitoring and controlling the two spacecraft during their 11-month journey to Mars. During this cruise phase, several mid-course propulsive maneuvers are planned to correct any errors in the spacecraft trajectories.

Late in June 1976, the first spacecraft will arrive at Mars and be placed in orbit by a commanded propulsive maneuver. The planet will then be surveyed by the Orbiter's instruments which will return the first Viking science data to the waiting science analysis teams at the SFOF. The preselected landing sites will be reviewed and the health of the attached Lander determined. If all appears well, after the spacecraft orbit is properly adjusted, the command will be send from earth for the first Lander to make its automatic landing on Mars around July 4, 1976. The second landing will occur about September 4. The nominal mission will end November 8, but an extended lifetime is likely.

Viking will require a large flight team of more than 700 persons because of the mission complexity. There will be four separate spacecraft to monitor, command, and receive science data from around the clock. Science data will be analyzed as rapidly as possible so that the mission sequences can be modified to achieve maximum scientific information.

Funds requested for FY 1976 and the transition period will be used for the following activities:

Orbiter Spacecraft - These funds will support the final assembly and test of spacecraft hardware, and launch and flight operations.

Orbiter Science - These funds will be utilized for final science tests and integration, science launch and flight operations, science team support, and science image processing and ground data handling.

Lander Spacecraft - The activities funded will be final test and integration, launch preparation and operations, flight operations, and prime contractor periodic award and mission success fees.

Lander Science - Funds requested are to support science launch and flight operations, lander investigation science teams and final assembly, integration, and testing of instruments.

Project Management - Requested funds will be utilized to make final Radioisotope Thermo-Electric Generator payments to the Atomic Energy Commission, to provide trajectory and software verification analysis, to provide for support service contracts, and to provide project reserve funds for problem resolution.

Outer Planets Missions
(Mariner Jupiter/Saturn 1977)

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)				
Project management	$2,497	$4,144	$3,806	$4,200	$1,600
Spacecraft design and development	13,116	47,503	47,782	58,800	14,800
Science	11,372	17,141	16,916	15,200	3,300
Mission operations	405	973	1,257	4,200	2,900
Total	$27,390	$69,761	$69,761	$82,400	$22,600
Titan/Centaur (Launch Vehicle Procurement Program)	($19,200)	($9,100)	($9,100)	($33,600)	($4,500)

OBJECTIVES AND STATUS:

In 1977, two Mariner-class spacecraft will be launched on a trajectory to Jupiter, and from Jupiter will continue on to Saturn on a space flight made possible only by a special alignment of Jupiter and Saturn. This alignment permits a spacecraft launched to Jupiter to reach Saturn in less than four years and eventually escape from the solar system through the acceleration provided by Jupiter's gravity. The opportunity to carry out such a fast gravity assisted swingby mission occurs approximately every 20 years. The spacecraft will encounter Jupiter in 1979 and Saturn in 1981. This important mission affords the chance to conduct comparative studies of the Jupiter and Saturn systems, including their satellites and the rings of Saturn, as well as to perform investigations in the interplanetary and interstellar media. One prime target will be the Saturn satellite Titan, which is comparable in size to the planet Mercury and is known to possess an atmosphere.

The use of a Mariner-class spacecraft with its ample power and precise pointing capability will permit the use of science instrumentation which is more sophisticated than that of Pioneer 10 and 11. The spacecraft will weight about 750 kg (1,652 lbs.), will use the Atomic Energy Commission's Multi-Hundred-Watt Radioisotope Thermoelectric Generators for power, and will carry approximately 95 kg (209 lbs.) of instruments. The spacecraft is being designed to make maximum use of residual Viking Orbiter hardware. The launch vehicle will be the Titan IIIE/Centaur D-IT, and the spacecraft will carry a propulsion module to provide the final required increment of injection velocity.

In FY 1975, Mariner Jupiter/Saturn (MJS '77) activities consist of the completion of the mission and systems level design, completion of the spacecraft detailed system and subsystem designs, and completion of the mission operations planning. Hardware fabrication will be completed for those items being obtained from add-on contracts to the Viking Orbiter procurements. By the end of FY 1975, parts will have been acquired and preparation for fabrication of the flight hardware will be underway. The testing of subsystems prototypes will be in process to provide the basis for the critical design reviews.

The Pioneer 10 encounter of Jupiter in December 1973 revealed intense fluxes of high-energy electrons within Jupiter's magnetosphere several orders of magnitude greater than had been predicted. This discovery has led to significant changes to the MJS '77 spacecraft design, with increased shielding and parts substitution undertaken to decrease sensitivity to radiation. Because of the increased scientific interest in the electromagnetic processes occuring within Jupiter's magnetosphere, a plasma-wave investigation was added to the MJS '77 science complement in place of an ultraviolet photometer.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

Changes within the elements of this project in FY 1975 were due largely to the substitution of the plasma-wave investigation for the ultra-violet photometer, a change in the propulsion module thruster configuration, and changes required to accomplish radiation hardening of the spacecraft to enable it to withstand Jupiter's environment.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Funds requested for FY 1976 and the transition period will be used as follows:

Project Management and Mission Design - Activities will consist of the detailed trajectory navigation and maneuver design, precision ephemeris development, and development of mission profile alternatives, in preparation for final selection of the flight trajectories in FY 1977.

Spacecraft Design and Development - Critical design reviews of all subsystems, which will begin in the last quarter of FY 1975, will be completed in the first quarter of FY 1976. Prototype fabrication and testing at the subsystem level will be completed coincident with the critical design reviews. Subsystem flight hardware will be fabricated and functionally tested. Type approval testing at the subsystem level will be accomplished during the last half of FY 1976, with some flight acceptance testing being started during the closing months. All engineering subsystems for assembly of the Proof Test Model (PTM) will be delivered to the JPL Spacecraft Assembly Facility and assembly will begin during the last two months of FY 1976. Assembly and testing will continue through the transition period. Computer software for the Command Control Computer, Attitude and Articulation Control Subsystem and the Flight Data Subsystem will be reviewed and accepted in mid-FY 1976. A Development Test Model and a Temperature Control Model will be assembled and tested during the year with results fed into final designs prior to PTM deliveries.

Science - Critical design reviews of all science instruments will be completed. The science activities for FY 1976 and the transition period consist primarily of the fabrication and testing of the science instruments.

Mission Operations - FY 1976 will be devoted to final work on the functional design of the mission operations complex and to initiation of the implementation of that design. Mission Computing System (MCS) computers will be in place early in FY 1976 so that software implementation can be initiated. All launch and Earth-Jupiter cruise requirements on the Tracking and Data System and MCS will be completed.

Pioneer/Helios -- Summary

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
			(Thousands of Dollars)		
Pioneer Venus	---	$27,100	$26,916	$57,600	$15,300
Pioneer 6-11	$5,680	5,000	5,326	3,900	900
Helios A&B	1,325	1,400	1,400	1,100	100
Total	$7,005	$33,500	$33,642	$62,600	$16,300
Centaur (Launch Vehicle Procurement Program)					
Helios	($21,600)	($7,100)	($7,100)	($400)	(---)
Pioneer Venus	(---)	(---)	(400)	(6,400)	(1,000)
Pioneer Venus					
Spacecraft	---	---	$16,816	$31,400	$8,000
Science	---	---	8,900	17,000	4,100
Operations	---	---	140	2,400	1,200
Project management	---	---	1,060	6,800	2,000
Total	---	$27,100	$26,916	$57,600	$15,300

OBJECTIVES AND STATUS:

The objective of the Pioneer Venus program is to conduct scientific investigations of the planet Venus, its atmosphere and its environment. There are two missions in the program: a multiprobe atmospheric mission and an orbiter mission. The multiprobe mission will investigate: the nature and composition of the clouds; the composition and structure of the atmosphere, including the minor constituents; the general atmospheric circulation pattern; and the structure of the ionosphere. The orbiter mission will: determine the detailed structure of the upper atmosphere; investigate the solar wind/ionosphere interaction region; determine atmosphere and surface characteristics on a planetary scale by remote sensing; and measure the gravitational field harmonics. The primary thrust of these missions is to determine the nature, dynamics, and evolution of the Venusian atmosphere. This goal has profound significance with respect to one of the objectives of the NASA Planetary program, namely, that of "determining the dynamic processes that shape earth's environment by investigation of other bodies of the solar system."

Dynamic modeling of earth's atmosphere for prediction of weather, climatic changes and pollution effects should be materially aided by the Pioneer Venus program. A second objective of this mission is to provide data to help understand the origin and evolution of the solar system by determining the relative abundances of the constituents of the Venus atmosphere and the mass properties of the planet.

The program is structured to achieve its science objectives at the lowest possible cost. Ample weight margins are being allowed to minimize the need for new development. The basic spacecraft will employ many existing subsystems, and will be "standardized" for easy adaptation to either a probe carrier or an orbiter configuration. This commonality concept will serve to minimize the total development cost for the two missions.

The orbiter mission will be launched with an Atlas/Centaur launch vehicle in May 1978. The orbiting spacecraft will weigh 320 kg (706 lbs.) in orbit and will carry 37 kg (81 lbs.) of scientific instruments. The multiprobe mission will be launched with an Atlas/Centaur in August 1978. A probe bus carrying 12 kg (26 lbs.) of scientific instruments will deliver one large probe with 28 kg (62 lbs.) of scientific instruments and three small probes with 2.1 kg (4.6 lbs.) of scientific instruments into the Venus atmosphere. Both missions will encounter Venus in December 1978 to provide synergistic study of the planet.

During FY 1975 funds are being used for spacecraft design, development and start of fabrication of test models.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

Refinements in the estimates for FY 1975 have resulted in a slight overall reduction.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Spacecraft - FY 1976 and transition period funds will support testing and start of fabrication of flight subsystems.

Science - Funds requested are for fabrication of design verification units, science support, and initiation of flight instruments fabrication.

Operations - Funds requested are for navigation and trajectory analysis and initiation of flight operations software tasks.

Project Management - Funds requested are to support mission design and definition and special mission parameter studies.

Pioneers 6-11

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Spacecraft	$1,015	$180	$210	---	---
Science	1,735	2,275	2,503	$2,585	$600
Operations	2,930	2,545	2,613	1,315	300
Total	$5,680	$5,000	$5,326	$3,900	$900

OBJECTIVES AND STATUS:

The Pioneer 6, 7, 8, and 9 spacecraft, launched 1965-1968, are continuing to obtain valuable data on the nature of the interplanetary environment in the region 0.75 and 1.1 A.U. from the sun. (One Astronomical Unit, or A.U., is 93 million miles, the mean distance between earth and the sun.) These data represent the information necessary to continue the study of the nature of the interplanetary environment near earth as well as to provide a correlation with similar information obtained from the Pioneer 10 and 11 spacecraft, farther out in the solar system.

Objectives of the Pioneer 10 and 11 missions are to conduct exploratory investigations of the interplanetary medium beyond the orbit of Mars, to determine the nature (distribution, size, and velocity of asteroids) of the Asteroid Belt, and measure the environment and atmospheric characteristics of the planet Jupiter. As the Pioneer spacecraft passed near Jupiter, instruments measured the magnetic fields, electromagnetic emissions, charged particles, and thermal balance associated with this largest planet of the solar system.

Pioneer 10 was launched in March 1972 and has now successfully traversed the Asteroid Belt and survived the radiation belts at Jupiter. Pioneer 11 was launched in April 1973, and has also completed its mission to Jupiter, measuring a new region of that planet. Excellent data have been obtained, both during the trip to Jupiter and in the vicinity of the planet. Results have revealed new information about Jupiter's magnetic field and intense radiation belts which are much different from those of earth. Helium has been detected in Jupiter's atmosphere for the first time, and valuable new data on this planet's mass and shape characteristics and its energy balance have been obtained. New information concerning Jupiter's moons has also been gathered, considerably changing previous conceptions of their mass, density, and size.

Tracking of Pioneer 10 will continue as it moves into interplanetary space beyond Jupiter. It is returning new information on the heliosphere and on low energy cosmic rays that transmit great amounts of energy from the stars but are too weak to reach earth. Using the increase in velocity obtained during its Jupiter flyby, Pioneer 11 will extend its investigation of the outer planets by continuing its flight to the first encounter of Saturn in 1979.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The FY 1975 increase in science and mission operations was the result of the additional analysis and operational support required to retarget the Pioneer 11 spacecraft in its approach to Jupiter so that it could continue its flight to Saturn.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATE:

Science - FY 1976 and transition period funds are required to support the analysis of the scientific data from Pioneers 10 and 11.

Operations - FY 1976 and transition period funds support flight operations, data processing, and mission analysis.

Helios A & B

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Science	$430	$755	$755	$750	$75
Operations	895	645	645	350	25
Total	$1,325	$1,400	$1,400	$1,100	$100

OBJECTIVES AND STATUS:

The Helios project is an international cooperative project between the Governments of the United States and West Germany. Its scientific objectives are to investigate the properties of, and processes in, interplanetary space in the region near the Sun, to within 0.3 A.U. The spacecraft, developed and built in West Germany utilizing consultants from the United States, weights about 364 kg (800 lbs.) and carries about 55 kg (120 lbs.) of scientific instruments. Three of the ten scientific instruments are supplied by U.S. investigators. NASA provides the launch vehicle and the tracking and data support for the first phase of the mission. West German technical personnel conduct the spacecraft operations and will operate the tracking systems and acquire the data during the later mission phase.

Helios A was successfully launched on December 10, 1974, and will make its closest approach to the Sun in March 1975. Helios B will be launched in early 1976.

Fiscal Year 1975 funds have been used to prepare the instruments for Helios A and to support their integration, testing, launch, and flight operations. Data analysis for Helios A, and preparation of procedures, software and instruments for Helios B are also being supported.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATE:

Science - During FY 1976 and the transition period, support of flight operations and data analysis for Helios A will continue. Helios B testing, launch and flight data analysis will also be supported.

Operations - FY 1976 and transition period funds are required for mission operations planning and for launch and flight operations.

Supporting Research and Technology/Advanced Studies

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Planetary science.....	$4,500	$4,600	$4,600	$4,600	$1,200
Exobiology.....	3,300	3,300	3,300	3,300	800
Planetary advanced studies.....	1,200	1,200	1,200	1,200	300
Planetary advanced technical development	2,195	5,200	5,200	5,200	1,300
Total.....	$11,195	$14,300	$14,300	$14,300	$3,600

The Supporting Research and Technology and Advanced Studies programs furnish essential support to the planning and conducting of flight programs. They serve as the foundation for defining science objectives and mission concepts. The scientific competence necessary for flight programs is established through these programs, and they also assure technological readiness and adequate planning for new projects at their inception.

Planetary Science

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$4,500	$4,600	$4,600	$4,600	$1,200

OBJECTIVES AND STATUS:

This program is subdivided into two major areas of research, planetary atmospheres and planetology. Research conducted under the planetary atmospheres program emphasizes the discovery and development of new techniques and experiments required for exploration and study of comets and the major planets in the late 1970's and early 1980's. The supporting theoretical studies and laboratory research necessary to lay the science foundation for future missions is being continued, as are similar tasks exploiting the results of previous flight experiments to arrive at a better understanding of the planets and their atmospheres.

In pursuing the basic objective of obtaining an understanding of planetary atmospheres, considerable progress has been made in understanding the nature and dynamics of the earth's atmosphere, and in describing the gross characteristics of the atmospheres of Mars and Venus. Experiments developed over the past five years are now assigned to or planned for flight missions to Mars, Venus, Jupiter and Saturn to obtain a more detailed understanding of their atmospheres. Similarly, the knowledge, techniques, instruments, and experiments being developed in the mid-1970's will form the basis for flight missions to comets and probes into the atmospheres of the planets in the early 1980's.

Tasks in planetology are directed at developing experimental concepts for determining formation history, composition and structure of planetary surface materials, and the nature and composition of planetary bodies.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATE:

During FY 1976, and the transition period, particular emphasis is being directed toward experiments to determine the planetary surface composition by in-situ and remote sensing techniques; such experiments are candidates for future missions. Emphasis will also be placed on the development of imagery experiments suited to particular requirements of investigations of Mars, Venus, and the outer planets, and on Mars-Earth comparative geology studies. Efforts will be directed toward Mercury-Mars-Earth-Moon analog studies to determine similarities between them.

Exobiology

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$3,300	$3,300	$3,300	$3,300	$800

OBJECTIVES AND STATUS:

This program is directed toward producing the answers to fundamental questions of extraterrestrial life and the origin of life. In past years, the program brought to breadboard status some of the key instruments that were selected for flight on the Viking Mars landers. Work is now being directed toward follow-on exploration of Mars as well as toward investigation and analyses of the complex and potentially "organic" atmospheres of Jupiter and Titan. The gas chromatograph to fly on Pioneer Venus is also a product of this program. In addition, work has been initiated on problems associated with the analysis and study of returned samples from another planet (e.g., Mars), from the point of view of life and organic molecules, as well as the problems induced by the possibility of back contamination.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

During FY 1976 and transition period, Exobiology will continue to support specific tasks in approximately 60 universities and two NASA centers in the areas of organic chemistry, organic geochemistry, the biology of environmental extremes, and the development of techniques of life detection. These tasks pursue the overall objective of studying other planets for evidence related to the presence of life and/or life related molecules. In addition, feasibility demonstration instruments will be developed for future missions to the planets, and ground-based research will be aimed at aiding in the ultimate interpretation of data returned from such investigations.

Planetary Advanced Studies

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$1,200	$1,200	$1,200	$1,200	$300

OBJECTIVES AND STATUS:

The purpose of the advanced studies project are to define mission concepts that are feasible for performing a systematic exploration of the solar system and to develop a rationale with schedule and resources requirements for conducting such missions in a logical, timely, and cost effective manner. Only with such advance effort can new mission opportunities be identified (e.g., multiple outer planet flyby opportunities) and new flight projects defined to the point where realistic cost estimates can be made. Advanced studies are performed both in-house at NASA centers and under contract. The studies cover the range from mission analysis and system feasibility to preliminary mission design and engineering.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

The FY 1976 and transition period program includes mission studies for the inner and outer planets, their satellites, and small bodies of the solar system (comets and asteroids) and general studies on adapting planetary spacecraft to the Space Shuttle/Tug.

Missions to be studied include: a Venus orbiter with synthetic aperture coherent radar to image and map the surface of Venus; a Jupiter orbiter to perform detailed studies of all of the Galilean satellites and of the temporal variations of the Jovian atmosphere and magnetosphere; Saturn orbiters, with the possibility of Titan probes; and missions to comets.

Planetary Advanced Technical Development

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$2,195	$5,200	$5,200	$5,200	$1,300

OBJECTIVES AND STATUS:

The Advanced Technical Development (ATD) program supports the planned and the advanced development of new and improved spacecraft technologies critically required for future planetary missions. It is under this program that the detailed planning for potential projects is performed and the technology readiness achieved that will place them on a firm basis for the development of realistic schedules and cost estimates. Methods for achieving cost effective missions through optimum utilization of existing spacecraft and subsystem design are a prime consideration.

During FY 1975 the preproject activities for the Pioneer Venus program were completed. The science payload was defined and instrument feasibility was established. This activity and support of Pioneer-class probe missions to the outer planets were the primary emphasis in FY 1975.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

During FY 1976 and the transition period, efforts to be emphasized will include preproject activity for a Jupiter Uranus mission opportunity in 1979. During that unique year, Jupiter can be used as a springboard to Uranus and even Neptune. Other major aspects of the program during FY 1976 will be directed toward the technology for delivery of a probe into the upper atmosphere of either Jupiter or Uranus and the feasibility of standardizing probe design for utilization throughout the outer planets system. The Pioneer Venus probe will provide the technological point of departure for the outer planet probe. Additional major activities will involve the identification of and conceptual solutions for the technological problems peculiar to Jupiter orbital missions. At a lower level of effort, planning will continue on an out-of-the-ecliptic mission, an early Comet Enke flyby using spare Mariner hardware, and for future spacecraft utilizing solar electric propulsion.

Planetary Astronomy

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$3,800	$4,200	$4,200	$4,200	$1,100

OBJECTIVES AND STATUS:

This continuing program makes important contributions to the scientific exploration of the solar system by observations of the planets and other solar system objects from the vicinity of Earth. New observation techniques, instruments, and platforms make it possible to acquire more information about the planets from the vicinity of Earth than previously possible. Observations are now made from airplanes, balloons, rockets, and earth-orbiting satellites as well as from ground-based observatories. Using the techniques of optical, infrared, radio and radar astronomy, observations can be made at almost all wavelengths. The large infrared telescope being built under the Construction of Facilities appropriation will add substantially to our capability. Results from the Planetary Astronomy program both supplement and complement the planetary flight programs.

The objectives of the program are accomplished through research projects which are carried out by the astronomers and other scientists located at NASA centers, universities, observatories, and other organizations.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In FY 1976 and the transition period, approximately 40 research projects will be conducted, ranging in size from the work of a single investigator to large multifaceted research projects at major observatories. The majority of the research projects require sustained effort over several years.

Major emphasis will be on studies of the outer planets from Jupiter through Pluto. This emphasis reflects our increased knowledge of Venus and Mars and a need for additional information on the other planets to support upcoming flight programs.

A recently completed NASA-supported addition of a high power radar system at the National Astronomy and Ionosphere Center at Arecibo, Puerto Rico, a National Science Foundation (NSF) facility, will be used in a program of planetary radar astronomy. Initial programs will include a study of Saturn's Rings and a high resolution mapping of the surface of Venus.

Planetary Data Analysis

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$1,400	$1,400	$1,400	$1,400	$400

OBJECTIVES AND STATUS:

The Data Analysis program provides support for scientific analysis after the period funded by the flight project. It also supports the analysis of flight data by scientists who were not members of the flight investigation team.

The long-term objective of Data Analysis is to fully analyze and interpret all the scientific data collected by flight projects and to insure the incorporation of these results into the growing body of knowledge about formation, history, and characteristics of the planets, asteroids and comets.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

During FY 1976 and the transition period, major emphasis in Planetary Data Analysis will be placed on conclusion of Mars geological mapping and analysis of the wealth of data obtained during the 11-month period in which Mariner 9 studied Mars, and on the analysis of data obtained by the very successful Pioneer 10 and 11 spacecraft on their Jupiter flybys. The studies of Venus and Mercury will be continued using the data obtained by the Mariner 10 spacecraft from its passage by Venus and its three passages past Mercury. Especially meritorious tasks analyzing the results of earlier Mariner and Pioneer missions to the planets and in interplanetary space will be continued as will tasks involving the interdisciplinary correlation and interpretation of collected data.

Planetary Quarantine

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$1,500	$1,500	$1,500	$1,500	$400

OBJECTIVES AND STATUS:

The objectives of the Planetary Quarantine program are to insure that no detrimental extraterrestrial life is introduced into the environment of earth, and that no other planet is detrimentally contaminated by terrestrial organisms through operations by U.S. spacecraft. The high priority of this activity has been repeatedly emphasized by the Space Science Board and the International Committee on Space Research. The results of this program are also required for compliance with Article IX of the Space Treaty of 1966.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Planetary Quarantine research in FY 1976 and the transition period will emphasize studies of the possibility that terrestrial micro-organisms can survive, but not reproduce, on the Mars surface. Studies of the new environment encountered in outer space that may sterilize spacecraft during transit will be continued. Studies will be supported at a low level, to better define the problems that will be encountered in maintaining effective quarantine against any detrimental extraterrestrial life brought to earth from other planets by future return missions. Operations in support of the Viking 1975 mission will be continued in FY 1976 to provide the required support, biological monitoring, and certification for that mission.

Planetary Flight Support

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$21,170	$25,500	$24,900	$29,300	$8,800

OBJECTIVES AND STATUS:

Tracking, telemetry, and command functions which support all planetary flight projects are funded under Planetary Flight Support. Support of these functions requires a highly sophisticated computer complex along with associated terminals, displays, and many other devices. The general purpose scientific and engineering computing at the Jet Propulsion Laboratory (JPL) is also supported with these funds.

Fiscal Year 1975 funds are being used to support Pioneers 6 through 11, including the highly successful Pioneer 11 flyby of Jupiter in December 1974; extended Mariner 10 mission with a second encounter of Mercury in September 1974 and a planned third encounter in March of 1975; the Helios A launch in December 1974 and subsequent Helios flight operations; final preparations for the Viking A and B launches in mid-1975; and beginning of the build-up to support the two Mariner Jupiter Saturn launches in 1977. This level of planetary activity is significantly higher than in 1974.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The reduction to the FY 1975 budget estimate was accomplished by deferring a minor portion of the planned equipment procurement for the support complex in order to partially fund Pioneer 11 retargeting and Mariner 10's third Mercury encounter.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

During FY 1976 and the transition period, funds will be used to continue support of Pioneers 6 through 11, the Helios A mission, and the Viking A and B missions. The build-up to support the Mariner Jupiter/Saturn missions will continue. Also, the design of a new approach to mission support to make the total system more reliable and flexible will be completed and the implementation of this new approach will begin. Again, this level of activity will be significantly higher than in FY 1975.

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Additional activities which will be supported from these funds during FY 1976 include:

1. Support of the tracking system analytic calibration effort.

2. Formulation of planetary programs data systems standards.

3. Management of the Operations Support Coordinating Office at JPL which concentrates on system analysis and design, and support of off-lab projects.

4. General scientific and engineering computing requirements.

5. Selected project-peculiar activities for all projects.

As these activities are not level-of-effort type, they may vary substantially from year to year. Some have been increasing steadily due to the increasing number of spacecraft which are being supported. The increase in funding from FY 1975 to FY 1976 reflects these increasing requirements and the continuing planning and implementation of updating, upgrading, and replacing various parts of the total support complex.

Lunar Research Program - Summary

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Lunar science SR&T...	$2,492	$3,500	$3,901	$4,700	$1,300
Lunar data analysis and synthesis.....	7,277	9,073	7,407	9,600	2,300
Lunar sample analysis	6,067	5,798	5,798	5,600	1,400
Lunar science operations.....	1,614	4,333	4,798	4,800	1,100
Total.....	$17,450	$22,704	$21,904	$24,700	$6,100

In the Lunar program a concentrated scientific effort is underway to analyze and interpret fully the large amount of data available from the lunar flight programs, ground-based studies of the moon, and laboratory investigations. The analytical work that has been carried out to date has revolutionized prior theories about the moon, yet the analysis is still in its early stages.

Lunar Science
Supporting Research and Technology

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$2,492	$3,500	$3,901	$4,700	$1,300

OBJECTIVES AND STATUS:

This program emphasizes scientific studies that provide a broad, sound base for the scientists engaged in analysis and synthesis of lunar data. With the exception of the still-operating Apollo Lunar Surface Experiment Packages (ALSEP) and the Laser Ranging Project, the Supporting Research and Technology (SR&T) program is presently the only source of significant new lunar data. Our SR&T activities emphasize studies in the following science areas: (a) earth-based observations, (b) analog studies, (c) theoretical studies, (d) laboratory simulations, and (e) extraterrestrial materials (primarily meteorites) studies.

New techniques and equipment have been developed for collecting lunar data by earth-based, multispectral, telescopic studies of the lunar nearside. Particularly rewarding are studies of the lunar surface reflection spectrum at near ultraviolet, visible and near infrared wave lengths which allow the determination of certain compositional properties of the surface material. This work is particularly enhanced by laboratory measurements of the optical properties of returned lunar samples and by our detailed geochemical knowledge of the Apollo landing sites.

This project also supports the activities of the Lunar Science Institute (LSI) adjacent to Johnson Space Center (JSC) and operated by the Universities Space Research Association (USRA). The LSI acts as a portal to the outside scientific community since it serves as an important data repository facility open to all qualified scientists, and enables these scientists to utilize the extensive scientific equipment at JSC.

Our advanced mission studies are concerned with evaluating, in view of our rapidly expanding knowledge engendered by Apollo and previous lunar flight data, the highest priority unanswered scientific questions and determining the optimum flight systems needed to collect the required data. Apollo surface experiments, returned samples, and data from the orbital experiments showed the existence of major geologic units which can be accurately mapped from orbit. Apollo also found significant gravity and magnetic anomalies.

We are now in a position to attack these and similar problems and complete the Apollo data set. This can be done by mapping from polar orbit both the radioactive and major rock-forming elements and the gravity and magnetic fields over the 80 percent of the moon not covered by Apollo, especially the critical farside and polar regions. Several approaches to such mapping have been examined in recent years.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The change in the FY 1975 budget estimate reflects an adjustment in the renewal (anniversary) dates of a number of research grants at universities, primarily to permit more orderly and efficient workload and financial planning at the institutions. This effort to bring the anniversary dates for such grants in the SR&T program into a common cycle with those for Lunar sample research and data analysis grants required funding some grants for periods of 14 to 18 months rather than one calendar year.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Fiscal Year 1976 and transition period funding is required for continued support to Lunar Science ground-based efforts, including telescopic observations and Lunar Science Institute activities. Definition studies will continue to examine the mission parameters, requirements and constraints of lunar polar orbit mapping missions, including possible Shuttle-launched automated lunar missions to be flown in the 1980's.

Lunar Data Analysis and Synthesis

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$7,277	$9,073	$7,407	$9,600	$2,300

OBJECTIVES AND STATUS:

The immediate objective of this work is the continued interpretation of the large and still growing body of data acquired by lunar missions and SR&T research and, by integrating these results, the enhancement of our knowledge of the origin, present characteristcs, and history of the moon. The longer term objective is to integrate such knowledge with that from terrestrial, planetary and solar studies, in order to gain a better understanding of the earth and the solar system.

During the Apollo flight phase of the program, the primary scientific effort was limited largely to reducing and analyzing the results of individual experiments. However, the vast body of acquired Apollo data, additional data from the still-operating Apollo lunar experiments, and data from the past automated lunar flight programs now require a major program of interdisciplinary analysis and synthesis which will provide the major scientific pay-off from the lunar flight programs. This new data analysis and synthesis program is receiving enthusiastic support from researchers with broad scientific backgrounds who desire to utilize these data in attacking the major problems of lunar orgin and history.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The FY 1975 estimate change reflects two factors: first, several ALSEP experiments ceased to function and data reduction funds for Principal Investigators were reduced; second, the funding for some data analysis and synthesis grants was rephased, resulting in a net reduction in FY 1975 funding.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In FY 1976 and the transition period, the scientific research of nearly 100 Principal Investigators will be supported by this program. Because many of these projects will require several years to reach fruition and because many new and outstanding scientists are expressing their desire to enter this program, we expect the total program to show steady improvement at a relatively constant funding level.

Also supported will be the Apollo Lunar Surface Experiment Package (ALSEP) Principal Investigators who are still reducing and analyzing the data received from the five ALSEP's operating on the lunar surface. Support is included for the lunar scientists at JSC who constitute NASA's focal point for lunar science.

Finally, work will continue in the reduction and analysis of the photos from the lunar mapping cameras flown on Apollos 15-17. The end point of this work is the cartographic products needed to support the present and future lunar scientific efforts.

Lunar Sample Analysis

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$6,067	$5,798	$5,798	$5,600	$1,400

OBJECTIVES AND STATUS:

Among the most important scientific information so far obtained from the moon is the extensive set of data on the chemical, isotopic, and physical characteristics of the lunar rocks and soil samples. These samples have already provided the essential elements of an absolute lunar chronology, and have led to models of lunar composition and evolution quite different from those anticipated prior to the return of lunar samples. In addition, data on the interactions of solar and interstellar products with lunar surface materials is leading to a far better understanding of the history of the sun and stellar processes in general.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

During FY 1976 and the transition period, it is planned that this project will continue to support the current level of 109 domestic Principal Investigators and 37 foreign investigators, as well as over 700 co-investigators. The funds are used to provide for salary support, computer efforts, supplies, and instruments for only the U.S. investigators. In order that major lunar questions can be answered, detailed investigations are being carried out by highly qualified Principal Investigator teams at institutions where unique research capabilities and skills have been developed. The success of the lunar sample program depends on our ability to fund and maintain these centers. In addition, keeping these centers viable will insure that their skills and capabilities are adopted by the scientific community and applied to significant earth applications such as: improved analysis of terrestrial measurements in the fields of biology, medicine or agriculture.

Lunar Science Operations

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$1,614	$4,333	$4,798	$4,800	$1,100

OBJECTIVES AND STATUS:

The full scientific potential of the Apollo Lunar Landing Missions is being realized with the continued operation of the five long-lived Apollo Lunar Surface Experiment Packages (ALSEPS) and the three laser ranging retro-reflectors emplaced at the Apollo 11, 14 and 15 landing sites. The ALSEP instruments, most of which were designed for a minimum lifetime of 12 months have continued to operate far beyond expectations. The Apollo 12 ALSEP passed its fifth anniversary of continuous operation on November 19, 1974.

Many of the experiments are still furnishing valid scientific information; no degradation of the retroreflectors has been detected. We will continue to operate these lunar systems as long as they furnish valuable scientific data. Annual reviews of all instruments are being conducted to verify the scientific validity and merit of each experiment. Continued observations under this task require support at Johnson Space Center (JSC): (1) to operate these instruments and to record and format raw data for Principal Investigators, (2) for Principle Investigators, who are familiar with instrument characteristics, to reduce raw data from these instruments to useful scientific observations, and (3) for these data to be placed in data banks where they will be available to all responsible scientific investigators.

The Sample Curatorial Facility is a major component of the post-Apollo scientific effort. Its operation involves support at Johnson Space Center (JSC) for handling, scoring, preparing and distributing lunar materials as well as documenting the history and data obtained on each sample and assuring their security. Only a small fraction of the material returned from the moon has been expended for scientific research to date. This practice will continue in order to preserve these unique materials for study by new and innovative techniques which may be developed in the future as well as for second generation analyses.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The change in the 1975 budget estimate reflects increases in several elements of cost associated with ALSEP data reduction, including computing rates.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

During FY 1976 and the transition period, the laser ranging program will continue at McDonald Observatory. The new observatory at Mt. Haleakala in Hawaii will begin its test runs in FY 1976. With the two stations producing range data, analysis will continue to develop new information on the dynamics of the earth-month system. The primary objectives include the study of physics of the moon, gravitation and relativity, and the physics of the earth. Significant secondary benefits that will increase our understanding of the earth are more accurate measurements of the wobbles of the earth's axis of rotation, which could enhance our capacity for earthquake prediction; and measurements of the relative motions between the continental United States and Hawaii, which would refine our theories on continental drift.

Continued support to the operating ALSEP's and to the Sample Curatorial Facility, will also be provided during this period. It is currently planned to improve the present JSC facility in order to provide increased security and assurance that these irreplaceable materials will not be compromised. As an added precaution a selected portion of this material will be placed in an especially prepared, secondary storage site, remote from the primary curatorial facility.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE — LAUNCH VEHICLE PROCUREMENT PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)				
Scout	$7,800	$13,800	$12,300	$12,100	$3,400
Centaur	106,000	75,000	75,400	113,800	26,400
Delta	60,200	47,700	51,800	36,600	10,300
Atlas-F	---	---	---	3,400	---
Supporting research and technology/ advanced studies	4,000	4,000	1,000	1,000	300
Total	$178,000	$140,500	$140,500	$166,900	$40,400
Distribution of Program Amount by Installation:					
Kennedy Space Center	$3,878	$10,415	$11,648	$15,160	$3,000
Marshall Space Flight Center	2,255	1,790	200	400	100
Goddard Space Flight Center	59,002	42,890	46,488	31,782	8,600
Wallops Flight Center	---	---	10	10	---
Jet Propulsion Laboratory	610	1,015	196	50	100
Langley Research Center	7,682	13,465	11,459	12,015	3,100
Lewis Research Center	102,574	68,675	68,044	102,168	24,700
Headquarters	1,999	2,250	2,455	5,315	800
Total	$178,000	$140,500	$140,500	$166,900	$40,400

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

OFFICE OF SPACE SCIENCE

LAUNCH VEHICLE PROCUREMENT PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION

The objective of the Launch Vehicle Procurement Program is to provide launch vehicles for automated space missions. The program includes procurement of vehicle hardware, launch services, engineering and maintenance support, in addition to providing for the product reliability improvement of vehicle and auxiliary ground support equipment. The program also includes Supporting Research and Technology/Advanced Studies effort to analyze future mission requirements and to investigate new technological developments. The vehicles currently being procured are: Scout, Delta, Atlas-F, Atlas Centaur, and Titan IIIE/Centaur. For a typical mission, vehicle hardware, i.e., the booster, upper stages, shrouds, adapters and other related equipment, is procured under a vehicle hardware category, all of which is readily identifiable with specific mission needs. Under the supporting activities category, launch preparations and operations are conducted, including launch services and engineering analysis for pre- and post-flight activities. Launches under this program are conducted from the Eastern Test Range in Florida, the Western Test Range in California, the Wallops Island Range in Virginia and the San Marco launch site off the east coast of Africa.

BASIS OF FUND REQUIREMENTS

Scout

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Hardware.....	---	$5,800	$4,100	$3,000	$500
Supporting activities.	$7,800	8,000	8,200	9,100	2,900
Total Scout.....	$7,800	$13,800	$12,300	$12,100	$3,400

OBJECTIVES AND STATUS

The Scout vehicle is the smallest launch vehicle employed by NASA. It is a four stage, all solid propellant launch vehicle, approximately 22.4 meters in length (73 feet). 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 555 kilometer (300 nautical mile) orbit. The Langley Research Center, located near Hampton Roads, Virginia, has managed the Scout project since its inception in 1959.

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 1975 BUDGET ESTIMATE

The change in FY 1975 funding plan is due to rephasing of hardware procurement. This allowed for an overall reduction of $1,500 thousand in FY 1975 Scout requirements.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Hardware - Funds will be utilized to continue hardware procurement to support Dual Air Density, Heat Capacity Mapping Mission, and the Stratospheric Aerosol and Gas Mission.

Supporting Activities - Engineering and technical support, vehicle test and checkout, launch operations, and maintenance of launch facilities and ground equipment will be funded to support the launch schedule.

Centaur

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Hardware	$63,800	$27,500	$26,000	$60,200	$10,600
Supporting activities	38,400	47,200	49,400	53,600	15,800
Major improvements	3,800	300	---	---	---
Total	$106,000	$75,000	$75,400	$113,800	$26,400

OBJECTIVES AND STATUS

The Centaur program provides for the procurement and launch of two booster stages, the Atlas and Titan, and an upper stage, the Centaur. Centaur is a high performance upper stage, the most powerful used by NASA for automated missions. It is currently 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 meter (10 feet).

A new configuration, the Titan Centaur, has been developed to support the Viking mission, and for other heavy payloads or high energy missions beyond the lifting capability of the Atlas Centaur. A proof launch was conducted in February 1974 to insure confidence in the mating of the Titan and the Centaur stage. The flight demonstrated the compatibility of the mating of the two stages and the adequacy of the Centaur standard shroud. However, a problem did occur in the propulsion system in the Centaur stage, which precluded gaining data applicable to the Viking and Mariner Jupiter/Saturn missions. Subsequently, a second Titan Centaur was successfully launched for the Helios-A mission on December 10, 1974. This flight demonstrated satisfactorily the full performance capabilities required for the Viking and Mariner Jupiter/Saturn missions. The Titan Centaur is 49 meters (160 feet) high and has a payload shroud diameter of 4.3 meters (140 feet).

CHANGES FROM FY 1975 BUDGET ESTIMATE

The change in FY 1975 funding plan for hardware is due to rephasing of hardware procurement in support of the High Energy Astronomy Observatory (HEAO) missions.

The change in FY 1975 funding plan for supporting activities is due to additional engineering support required for the design effort associated with the failure of the Titan/Centaur Proof Flight, and corrections to electronic components of the Centaur inertial guidance system.

The change in FY 1975 funding plan for major improvements reflects the shift of these funds into supporting activities to carry out the corrective actions referred to above.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Hardware - Funds are required to continue incremental procurement of hardware to support Helios-B, Viking-A, Mariner Jupiter/Saturn-A and -B, High Energy Astronomy Observatory (HEAO) -A, -B, and -C, and Pioneer Venus-A and -B missions.

Supporting Activities - Funding will be utilized for management and engineering support effort, launch support operations, field services, and to maintain facilities and ground equipment.

Delta

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Hardware	$24,500	$12,800	$17,400	$12,300	$1,000
Supporting activities	34,700	32,900	34,400	24,300	9,300
Major improvements	1,000	2,000	---	---	---
Total	$60,200	$47,700	$51,800	$36,600	$10,300

OBJECTIVES AND STATUS

The Delta launch vehicle is the most used vehicle in the NASA launch vehicle family. Since its first use in 1960, this vehicle has been utilized in 106 launches and has experienced a success record of 90 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 3, 6, or 9 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 stabilized. This vehicle in its three stage configuration is approximately 35.05 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 pound) into a 555 kilometer (300 nautical mile) orbit.

During 1974, this vehicle system experienced a launch failure in launching the Skynet IIA mission in January 1974, as was covered in our testimony in review of the FY 1975 budget last year. Subsequently, vehicle anomalies occurred during the launches of Westar A in April and SMS-A in May, 1974. All launch activity was stopped until October 1974 while an overall technical and management review of the project was conducted. The review committees recommended a series of hardware modifications which have been implemented. In addition, the committees recommended changes in project management, practices, staffing levels for certain key activities, and operating procedures to improve the reliability of the Delta. Launch activity has been resumed, and a number of missions have been successfully launched.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The change in FY 1975 funding plan for hardware is due to rephasing of procurement for Nimbus-G, International Ultraviolet Explorer (IUE) and International Sun-Earth Explorer (ISEE) missions, which require earlier obligation of funds than previously anticipated.

The change in the FY 1975 plan for supporting activities is due primarily to the added engineering effort attributable to the launch failure in the Skynet IIA mission and anomalies in the SMS-A and Westar-A missions. Corrective actions such as contamination control, improved vibration testing techniques and procedures and changes in materials and design required additional funds.

The deletion of major improvement activity in FY 1975 is due to the use of these funds for activities associated with the recommendations of the failure review committees.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Hardware - Funds will be used to continue the hardware procurement contracts initiated in FY 1973 and 1974 and to be initiated in FY 1975 in support of International Ultraviolet Explorer-A (IUE), Nimbus-G, International Sun-Earth Explorer A/B and C (ISEE), and the LANDSAT-C missions.

Supporting Activities - Necessary technical and engineering support, to sustain vehicle test and checkout and launch operations and to support maintenance of launch facilities and ground equipment, will be provided with FY 1976 and transition period funds.

Atlas-F

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Hardware.....	---	---	---	$3,400	---

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.

BASIS FOR FY 1976 AND TRANSITION PERIOD ESTIMATE

Funds requested for FY 1976 will be used to initiate work to refurbish and modify the Atlas-F for the launch of the Tiros-N meterological satellite. The Tiros-N mission is planned to be launched in early CY 1978.

Supporting Research and Technology/ Advanced Studies

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Advanced studies.....	$1,257	$1,535	$700	$700	$100
Propulsion and energy conversion.....	1,639	1,330	214	50	100
Guidance, control and navigation.....	669	735	---	200	100
Vehicle engineering.....	210	175	52	50	---
Instrumentation and electronics.....	125	125	34	---	---
Structures and materials.....	100	100	---	---	---
Total.....	$4,000	$4,000	$1,000	$1,000	$300

OBJECTIVES AND STATUS

The objective of the Supporting Research and Technology (SR&T)/Advanced Studies project is to provide preliminary data and alternatives to management so that decisions concerning the space transportation system may follow a well defined, integrated course in future years.

In FY 1975, the Advanced Studies program is directed toward investigations of a solar electric propulsion stage for use with the Shuttle/Tug or conventional launch vehicles for both earth orbital and planetary mission application. The SR&T program is directed at improving reliability, cost, and safety of launch vehicles and determining their environmental effects. Activities include testing and evaluation of inertial components and evaluation of the most cost-effective use of new electronic technology in guidance control computer applications.

CHANGES FROM FY 1975 BUDGET ESTIMATE

Decreases in the FY 1975 funding plan are the result of funds having been reprogrammed to meet the more urgent requirements to carry out corrective actions in Centaur and Delta.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Advanced Studies - Solar electric propulsion advanced studies will be continued. Launch vehicle phase out studies will be initiated in order to insure an orderly transition of our current vehicle usage to the Space Shuttle.

Propulsion and Energy Conversion - Solar array technology for solar electric propulsion and research in solar electric propulsion system capabilities will be continued.

Guidance, Control, and Navigation - Development, test, and evaluation of strap down guidance system components consisting of inertial sensors and computer technology will be continued.

Vehicle Engineering - Investigation of atmospheric effects resulting from effluents produced during vehicle launching activities will be continued.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

BUDGET SUMMARY

OFFICE OF APPLICATIONS — SPACE APPLICATIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Weather and climate...	$50,926	$35,000	$36,500	$33,600	$11,700
Pollution monitoring..	11,596	29,800	22,400	19,200	8,700
Earth resources survey	47,488	58,600	60,600	62,030	15,000
Earth and ocean physics.....	10,400	18,500	18,900	26,400	7,800
Space processing.....	2,825	3,500	3,300	3,700	1,200
Communications.....	22,300	8,300	11,000	7,500	2,000
Data management.....	---	4,000	4,000	4,000	1,500
Shuttle payloads.....	4,500	4,500	4,500	3,000	1,500
Advanced applications flight experiments..	4,700	4,700	4,700	4,700	1,300
Applications systems analyses.....	1,265	5,000	5,000	5,000	1,400
Applications explorer missions.....	---	2,600	2,600	5,900	2,600
Earth observation satellite definition	3,000	1,000	1,000	---	---
Total.....	$159,000	$175,500	$174,500	$175,030	$54,700
Distribution of Program Amount by Installation:					
Johnson Space Center..	$18,133	$31,700	$32,400	$33,030	$9,500
Kennedy Space Center..	285	1,400	1,200	1,300	200
Marshall Space Flight Center.....	4,155	4,800	7,100	6,500	2,050
National Space Technology Laboratories.	---	200	200	200	50
Goddard Space Flight Center.....	100,285	89,100	92,200	86,400	30,100
Jet Propulsion Laboratory.....	4,757	3,200	9,600	14,400	4,500

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Wallops Flight Center.	$6,267	$7,700	$7,300	$9,300	$1,900
Ames Research Center..	6,598	7,100	5,700	5,400	1,600
Langley Research Center.....	8,749	8,400	8,900	9,300	2,700
Lewis Research Center.	3,935	2,100	2,600	2,500	400
Headquarters.....	5,836	19,800	7,300	6,700	1,700
Total.....	$159,000	$175,500	$174,500	$175,030	$54,700

RD 7-2

51-423 O - 75 - 16

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

OFFICE OF APPLICATIONS

SPACE APPLICATIONS PROGRAM

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Weather and Climate:		
All Weather Atmospheric Sounding Experiments Satellite	Launch of NIMBUS F	1975
Operational Temperature Sounding Satellite	Launch of TIROS-N	1978
Cloud Imaging from Synchronous Satellites	Launch of SMS-B	1975
Global Atmospheric Research Program	GARP Atlantic Tropical Experiment	1974
	Data Systems Test	1975-76
	First GARP Global Experiment	1977-79
Meteorological Sounding Rockets	Launch about 300 annually	
Pollution Monitoring:		
Oceanographic and Air Pollution Observing Satellite	Launch of NIMBUS G	1978
Earth Resources Survey:		
Earth Resources Technology Satellites	Launch of LANDSAT-B	1975
	Launch of LANDSAT-C	1977
Earth and Ocean Physics:		
Geodynamic Experimental Ocean Satellite	Launch of GEOS-C	1975
Ocean Dynamics Satellite	Launch of SEASAT-A	1978
Laser Geodynamics Satellite	Launch of LAGEOS	1976

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Space Processing:		
Sounding Rocket Missions	Launch about 6 annually	
Communications:		
Cooperative Applications Satellite	Launch of CAS-C	1975
Applications Explorers:		
Heat Capacity Mapping Mission	Launch of HCMM	1977
Stratospheric Aerosols and Gas Experiment	Launch of SAGE	1979
Reimbursable Missions:		
ITOS*	Launch of ITOS E2-I	1975-1978 (Subject to call-up by NOAA)
GOES*	Launch of GOES A-C	1975-1977 (Subject to call-up by NOAA)
	Launch of GOES D, E, F	1980-1985 (Subject to call-up by NOAA)
NOAA*	Launch of NOAA A-G	1978-1989 (Subject to call-up by NOAA)

* National Oceanic and Atmospheric Administration (NOAA) funded.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

OFFICE OF APPLICATIONS — SPACE APPLICATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objective of the Space Applications program is to conduct research and development activities that demonstrate the applications of space-related technology, systems and other capabilities which can be effectively applied and used in the civil sector for practical benefits to mankind. Generally, these R&D activities are grouped in the following areas: Weather and Climate, Pollution Monitoring, Earth Resources Survey, Earth and Ocean Physics Applications, Space Processing, Communications, Data Management, and Application Experiments and Studies.

In each of these areas, programs are being planned to make substantive contributions to solving pressing national problems and meeting national needs.

Weather and Climate - Reliable short- and long-term weather forecasts can mean savings of life, property, and money. The Weather and Climate program is directed toward the application of satellite data to problems in detection, prediction, and early warning of severe storms and the improvement of our capability for mid-range (1-14 days) and long-range (climatic) weather prediction. The atmospheric processes associated with these phenomena, i.e., severe storms, daily weather and climate, require different approaches and differing satellite systems to provide the data to achieve better forecasts. The major activities in FY 1976 and the transition period will be: (1) continued emphasis on applied research and technology; (2) severe storm research; (3) the prototype development of the third generation NOAA operational weather satellite (TIROS-N); and (4) planning for the first international Global Atmospheric Research program experiment to be conducted in CY 1978. A significant activity proposed for FY 1976 is the continued augmentation of the Severe Storm Research program including the definition of STORMSAT. This satellite would observe those short-lived and violent meteorological features which describe and are associated with severe storms, e.g., thunderstorms and tornados, and provide a capability for improved warnings to the population as to their formation and path.

Pollution Monitoring - Man must learn to achieve progress while living in harmony with his environment. The monitoring of the environment is an important aspect of this task. The Pollution Monitoring program has as its objective the development and demonstration of systems capable of identifying and measuring pollutants in the air and water on global and regional scales. This will be done by: (1) determining the present

composition of the atmosphere for use as a baseline against which the long-term trends of atmospheric pollutants can be measured; (2) monitoring changes in the composition from established norms with respect to time and place; and (3) incorporating the data describing atmospheric constituents and their behavior into circulation related environmental quality models

Additional significant data will also be obtained by the second Application Explorer Mission--the Stratospheric Aerosol and Gas Experiment (SAGE)--which will fly a single instrument to direct and map stratospheric aerosols and gas concentrations. The information derived will complement that obtained by the Nimbus-G program currently under development.

Earth Resources Survey - The effective utilization of the world's natural resources requires that their extent be surveyed, their changes be monitored and that systems for wisely managing their exploration be constructed. In the Earth Resources Survey area, two objectives have been established: (1) to develop the capabilities for remotely sensing the earth's resources from aircraft and spacecraft in order to perform comprehensive global surveys; and (2) to apply these to oceanography, geology, hydrology, geography, and cartography. Achieving these objectives will provide an information base that can be used in the world's resources management.

Significant activities being continued are involved with the Applications Systems Verification Tests program (ASVT) and Landsat-C. The ASVT program is designed to demonstrate to the user community that remotely obtained information (from satellites and aircraft) provides entirely new capabilities that may efficiently supplement and/or complement existing data gathering systems. The most significant demonstration taking place in FY 1975 and FY 1976 is the Large Area Crop Inventory Experiment (LACIE), an experiment using Landsat data to determine wheat production over the North American continent with possible extension to the entire world. Landsat-C, an Earth Resources Technology Satellite just getting underway, will provide greater resolution and additional information as well as continuity. It will differ from the earlier Landsat 1 and B in that (1) the resolution of the Return Beam Vidicon system will be increased twofold, a change fully supported by the Department of Interior and many other Government agencies, and (2) the Multispectral Scanner will incorporate a thermal sensing capability (Fifth Band), providing better discrimination of both land and water features.

Earth and Ocean Physics Applications - This program provides a focus for the use of space platforms and related research efforts to acquire data on the dynamic qualities of the earth and oceans. The study of ocean dynamics from space provides data for ocean research which can lead to major advances in our ability to predict sea conditions. The benefits of such a predictive capability include improved ship routing, advanced ocean structures design, storm damage avoidance, and coastal protection and development. The SEASAT-A satellite, now under development, is a significant forward step in achieving this predictive capability. Earth dynamics research is centered on the study

of the motions of the large solid plates (tectonic plates) which make up the surface of the earth. The motion of these tectonic plates is one of the causes of large earthquakes. Measurement of these motions using both the LAGEOS satellite which will be launched in 1976 and accurate ground measurements will permit a better understanding of this dynamic process and may lead to an earthquake prediction capability.

Space Processing - The objective of this program is to exploit the unique characteristics of zero gravity to prepare and process materials in ways that are not possible or economically practical on earth. The eventual benefits of the program are expected to include new knowledge of materials and technology improvements. These will be directly applicable to industrial and biomedical processes on the ground as well as the unique new products produced in space.

Communications - From the inception of the space age, NASA has engaged in a vigorous research and development effort that has clearly demonstrated the viability of satellite-based communications systems. The current NASA effort is directed toward the development of advanced technology and the performance of the Agency's responsibilities to provide expert advice and consultation on satellite communications to various Government departments and agencies. The highly successful series of Applications Technology Satellites (ATS-1, 3, 5, and the recently launched ATS-6) will be continued to be used by various domestic and international experimenters. Two important experiments involving ATS-6 are the Health and Education Television Experiment being conducted with the Department of Health, Education and Welfare and the Satellite Instructional Television Experiment in cooperation with the Government of India.

Data Management - Data Management activities are directed toward the systematic study, design, development, and demonstration of the technology needed to improve the flow of data from the initial collection by satellite to the user. Satellite systems being developed in the Applications program will require the extension of current technology to accommodate the increased volume, complexity, and exceedingly high rates of data, and reductions in origin-to-user transmission times. The user must also be provided with improved capabilities for rapidly storing, maintaining, and retrieving the required data products.

Applications Experiments and Systems Analysis - The Advanced Applications Flight Experiments program provides for the early design and development of sensors and experiments prior to committing them to flight on a mission. This approach avoids the high costs associated with a premature commitment of new technology. Applications studies and systems analyses are undertaken to add assurance that the research and development activities of the Applications program are practical and cost-effective, and based on established user needs and requirements. To accomplish this objective, special emphasis is placed on user-oriented economic analyses and assessments of ongoing and proposed new programs. A major consideration in such investigations is to establish need and economic justification. These are performed as early in the life of a program activity as possible and updated through follow-on studies as more detailed information is developed.

BASIS OF FUND REQUIREMENTS:

WEATHER AND CLIMATE

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)				
All weather atmospheric sounding experiment satellites (Nimbus 5 and F)	$16,400	$7,000	$9,300	$3,500	$900
Operational temperature sounding satellite (Tiros-N)	10,000	9,000	7,500	9,000	2,100
Operational satellite improvements	2,500	3,500	3,500	5,000	2,400
Global atmospheric research program (GARP)	5,698	7,400	7,200	7,000	3,000
Meteorological sounding rocket program	1,500	1,700	1,500	1,900	600
Severe storm observations satellite (Stormsat) definition studies	---	---	---	1,500	300
Advanced techniques in observing and forecasting	4,828	5,000	5,400	5,700	2,400
Cloud imaging from synchronous satellites (SMS 1 and B)	10,000	1,400	2,100	---	---
Total	$50,926	$35,000	$36,500	$33,600	$11,700

The main objective of the Weather and Climate program is directed toward the application of satellite data to problems in detection, prediction, and early warning of severe storms and the improvement of our capability for mid-range and long-range (climatic) weather prediction. The atmospheric processes associated with these phenomena, i.e., severe storms, daily weather, and climate, require different approaches and differing satellite systems to provide the data to achieve better forecasts. Severe storm forecasting requires the measurement of local atmospheric changes over a period of minutes to hours on an around-the-clock basis, a unique capability of the geosynchronous satellite, while daily and climatic forecasting require an ability to measure detailed changes over extended periods of time on an integrated global basis, a capability of the polar-orbiting satellite.

Severe storm research will apply the continuous observations from geostationary orbit to the problem of detection and prediction of short-lived, violent storms. The short life time of tornadoes, for example, requires high-resolution observations with a frequency on the order of minutes. The capability to selectively measure the atmospheric structure on a nearly continuous basis and improved data manipulation and analyses procedures provide the research tools which will lead to significant improvement in severe storm forecasting.

Satellites making important contributions toward improvements in our weather forecasting capability include the polar-orbiting satellites of the Improved TIROS Operational Satellite (ITOS) series developed by NASA for the National Oceanic and Atmospheric Administration (NOAA); the Synchronous Meteorological Satellite/Geostationary Operational Environmental Satellite (SMS/GOES) series; and the Nimbus research and development polar-orbiting weather satellite series. The polar-orbiting satellites provide quantitative soundings of the global atmosphere for use in numerical weather forecasting, data for advanced research on atmospheric processes, and global viewing of clouds and storm systems. A prototype of the third generation operational satellite of this kind (TIROS-N) is currently under development. The geostationary satellites (the first operational prototype was launched in early 1974) provide continuous viewing of the earth-atmosphere for nearly real-time surveillance of changing weather features.

The Ocean Dynamics Satellite, SEASAT-A, and the Oceanographic and Air Pollution Observing Satellite, Nimbus-G, will also make important contributions to weather forecasting by providing additional data (e.g., sea surface temperatures, wave heights and lengths, surface wind speed and direction, and measurements of the earth's radiation budget and minor atmospheric constituents) essential to the study of the ocean-atmosphere energy exchange processes.

All Weather Atmospheric Sounding
Experiment Satellites (NIMBUS 5 and F)

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Spacecraft	$8,161	$3,430	$4,295	$2,500	---
Sensors and data analysis	7,222	2,270	3,432	400	$200
Ground operations	1,017	1,300	1,573	600	700
Total	$16,400	$7,000	$9,300	$3,500	$900
Delta (Launch vehicle procurement program)	($1,100)	(---)	(---)	(---)	(---)

OBJECTIVES AND STATUS:

The major objectives of the All Weather Atmospheric Sounding Experiment Satellites (Nimbus 5 and F) are to provide data on a global basis for more accurate long term weather forecasts. Toward this end, sensors aboard Nimbus 5 and F are designed to provide measurements of the atmosphere's structure and composition between the surface and the upper reaches of the stratosphere. Advanced infrared and microwave sensors are being flown to provide all-weather global data with improved vertical resolution and to a higher range of altitudes than previously obtained.

Nimbus F will also provide basic data to assess the role of incoming solar radiation and the earth's outgoing radiation on large-scale weather systems. Another experiment aboard Nimbus F will provide information on tropical and southern hemisphere wind and temperature structures. In addition to the study and analysis of the data from these experiments by the principal investigators, the data is also provided to the scientific community such as participants in the Global Atmospheric Research program, the Goddard Institute for Space Science, the National Oceanic and Atmospheric Administration, and others for further analysis and model development and incorporation into a better understanding of the atmosphere and improved forecasting.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The increase in the FY 1975 Budget Estimate is required due to physical problems experienced in the development of the Nimbus-F payload. Delays in the delivery of several of these instruments also led to delays in the scheduled launch date, thereby increasing spacecraft, sensors and ground system contractor support costs.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Final Nimbus-F spacecraft pre-launch systems tests were conducted in FY 1975 in preparation for a launch in late FY 1975. Orbital operations and data acquisition and analysis for Nimbus-4 and -5 were also continued during FY 1975.

During FY 1976 and the transition period, some data will continue to be collected and analyzed from Nimbus-5, although primary emphasis will be placed on the collection and analysis of the data obtained from Nimbus-F. Supplementary measurements will be made for the First GARP Global Experiment (FGGE) by tracking and relaying data from approximately 300 balloons through a special Nimbus-F system during the Tropical Wind, Energy Conversion and Reference Level Experiment. Nimbus-F will also serve as a tracking and data relay platform for a large number of globally-distributed remote data sites measuring ice movement and status, ocean current flows and other related data. The ability to accurately track a low earth orbital satellite from a synchronous altitude satellite will be demonstrated in an experiment conducted in conjunction with the Applications Technology Satellite-6. New

and, in some instances, improved techniques for determining on a global basis the status and distribution of ocean conditions, and atmospheric distributions of certain gases will also be demonstrated. It is expected that these techniques and the measurements obtained will significantly improve our knowledge of the factors which influence weather and atmospheric modifications.

Operational Temperature Sounding Satellite (TIROS-N)

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Spacecraft and support...	$6,323	$7,000	$4,482	$5,500	$1,700
Sensor development.....	3,677	2,000	3,018	3,300	300
Operational station equipment.....	---	---	---	200	100
Total.....	$10,000	$9,000	$7,500	$9,000	$2,100
Atlas-F (Launch vehicle procurement program)...	(---)	(---)	(---)	($3,400)	(---)

OBJECTIVES AND STATUS:

The objectives of the Operational Temperature Sounding Satellite (TIROS-N) program are to develop both an advanced operational prototype satellite and the sensors capable of meeting the National Operational Environmental Satellite System and the Global Atmospheric Research program requirements for improved environmental data and better data handling capability. These requirements include a higher resolution day/night capability to make cloud cover observations on a local and global scale; improved observations of vertical temperature/moisture profiles; and a high capacity data collection and relay and platform-location system.

TIROS-N is the R&D protoflight spacecraft for the third generation of operational weather satellites. In accordance with the basic agreement between the Department of Commerce and NASA, the Department of Commerce will fund follow-on operational satellites of the TIROS-N configuration, although NASA will continue to build and launch the spacecraft and then check out spacecraft operations in orbit prior to turning over the operational responsibility to the National Oceanic and Atmospheric Administration (NOAA). The spacecraft which will carry the sensors is a modification of the 5-D spacecraft being built by RCA for the Defense Meteorological Satellite program; NOAA, NASA, and the Department of Defense are all planning to use this spacecraft in order that the costs of a separate development program can be avoided.

The TIROS-N sensors are being developed to take advantage of advancements in technology, particularly in microwave sounding and infrared imagery, to meet the increased requirements indicated above. The microwave sounding capability will provide a means of penetrating the clouds which continually cover much of the earth. Microwave sounding, coupled with infrared imaging, will provide an all-weather, day-and-night measurement capability; such data is fundamental to accurate global numeric weather forecasting. In addition to its complement of sensors, TIROS-N will include an operational data collection system capable of receiving, processing, and retransmitting sensor data from buoys, balloons, aircraft, and remote ground stations. This system will obtain meteorological measurements not otherwise available in tropical and Southern Hemisphere ocean regions for the Global Atmospheric Research program (GARP).

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The reduction in the FY 1975 Budget Estimate is due to a delay in the initiation of the spacecraft development phase incurred to permit more detailed studies of the 5-D spacecraft and the necessary modifications for the TIROS-N configuration to be performed.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

During FY 1975, the TIROS-N sensors continued under development, the spacecraft definition study was completed by RCA, specifications were prepared, and the spacecraft development contract awarded.

Efforts during FY 1976 and the transition period will include the detailed design of the spacecraft structure, spacecraft data handling system, and ground support equipment. Spacecraft subsystem manufacturing, fabrication, and test will be initiated. The development of the sensors will continue, including breadboard buildup and the fabrication and testing of the engineering models. The protoflight sensors will subsequently be tested and delivered to the spacecraft. Contract award for instrument integration, storage, call-up, launch, and post-launch support is also scheduled for this period. Launch is currently scheduled for 1978.

Operational Satellite Improvements

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$2,500	$3,500	$3,500	$5,000	$2,400

OBJECTIVES AND STATUS:

The objective of the operational satellite improvements program is the conduct of research and development for specific improvements to advanced sensors, spacecraft subsystems, and ground equipment in support of present and future operational satellite systems.

Current developments include modifications to the Vertical Temperature Profile Radiometer (VTPR) now being flown on the NOAA ITOS weather satellite to improve the accuracy and utility of this sensor; modifications of the Advanced Very High Resolution Radiometer (AVHRR) to add a fifth spectral channel to provide improved sea-surface temperatures for operational use, and modifications to the Visible Infrared Spin-Scan Radiometer (VISSR) being flown on the Geostationary Operational Environmental Satellites (GOES) to provide an atmospheric sounding capability. All these efforts are coordinated with the National Oceanic and Atmospheric Administration (NOAA).

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In FY 1976 these efforts will be continued and development of an all-weather microwave sounding capability for follow-on satellites of the TIROS-N series will be initiated. All-weather soundings of greater accuracy are essential to better numerical weather prediction and must be provided if improved weather forecasts are to result. Also, the development of local user terminal ground equipment for readout of data from both polar-orbiting and geostationary weather satellites will be continued in response to long unfilled user community needs for such low cost equipment.

Development will also be initiated on a sounder for a 3-axis stabilized geostationary spacecraft. This effort, based on preliminary work funded under the Advanced Applications Flight Experiment (AAFE) program, is in response to a NOAA requirement for an atmospheric sounder on a geostationary satellite providing data which are improved in both resolution and accuracy for use in severe storm detection and forecasting.

Global Atmospheric Research Program (GARP)

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Data systems test support..	$1,359	$1,340	$1,295	$500	$80
Simulation studies.....	3,098	3,601	4,230	4,800	2,400
First GARP global experiment.....	400	956	156	1,200	450
GARP atlantic tropical experiment support.....	624	1,165	1,074	---	---
Technology support.....	217	338	445	500	70
Total.....	$5,698	$7,400	$7,200	$7,000	$3,000

RD 7-13

OBJECTIVES AND STATUS:

The Global Atmospheric Research Program (GARP) is a long-term, world-wide international effort sponsored by the World Meteorological Organization of the United Nations and the International Council of Scientific Unions. The major objectives of GARP are improving the accuracy and length of time over which weather forecasts can be made and understanding the physical processes that affect climate and create climatic change. In pursuing these objectives, the current program centers on the design and testing of a series of atmospheric numerical models to permit an increasingly precise description of atmospheric behavior, and observational and experimental studies of the atmosphere for the design of such models and for the testing of their validity.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

A one year delay in the start of the First GARP Global Experiment resulted in a reduction in overall funding requirements in FY 1975, and allowed additional FY 1975 funds to be provided for simulation studies at the Goddard Institute of Space Studies in support of the GARP Atlantic Tropical Experiment.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In early FY 1975 NASA participated in the first large-scale international GARP experiment--the GARP Atlantic Tropical Experiment--with the ship Vanguard, the CV-990 aircraft, and the SMS-1, ATS-3, and Nimbus-5 satellites. In May 1974, a Data Systems Test was conducted that produced the first global real time data set. The Data Systems Test focused attention on problems related to the acquisition and processing of global data from many data sources, as will be the case in the 1977-79 period of the First GARP Global Experiment. The Data Systems Test consisted of the simulation of a DST data management system, and the implementation of a data utilization program for application of the data sets; the focus of this work was on uncovering the potential difficulties that may arise in meeting the First GARP Global Experiment objectives.

In October 1974, a preliminary Data Systems Test was completed using wind vector data from the SMS-1 cloud images in real time. Also in FY 1975, the U.S. plan for the First GARP Global Experiment will be completed and distributed for comment. Testing and evaluation of the Carrier Balloon System will continue during this period.

In FY 1976 and the transition period, further Data Systems Test periods are scheduled to provide global data sets during summer and winter weather conditions; these tests will use data obtained from the Nimbus-F and SMS-B weather satellites and also the data relayed from ocean buoys and carrier balloons through Nimbus-F. Planning and associated research will be accelerated in preparation for the First GARP Global Experiment. Research

in numerical methods weather forecasting will concentrate on the development of new technologies to use meteorological satellite data in atmospheric circulation and operational weather forecast models. Global data sets of higher quality than those previously obtained will be produced and used in experiments.

Meteorological Sounding Rocket Program

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)				
Procurement and launch of research sounding rockets	$500	$700	$700	$800	$200
Development of sounding rocket systems	200	100	100	---	---
Field experiment support	800	900	700	1,100	400
Total	$1,500	$1,700	$1,500	$1,900	$600

OBJECTIVES AND STATUS:

The major objective of the Meteorological Sounding Rocket program is to explore the atmosphere from 30 to about 100 km to gain a better understanding of its structure and composition, and how it reacts with and affects weather phenomena in the lower atmosphere. Data obtained by rockets at these altitudes are used to study the composition and chemical processes related to upper air pollution, chemical dynamics, and their effects on climate and man's health. Part of the program is a cooperative international effort to obtain and analyze mutually useful data which will permit analyses of upper atmospheric phenomena in both the eastern and western hemispheres such as stratospheric warmings and stimulate the use of the data for practical applications.

Data from meteorological rockets are also used to calibrate temperatures obtained from satellite remote sensors. These comparative data permit corrections to be made to the radiance weighting functions, and thereby produce more accurate temperatures from satellite observations. Improvements of the design and operation of aeronautical and space vehicles flying through the atmosphere and into space also require data on the variations of atmospheric density and circulation, as well as data on sudden stratospheric warmings with major density changes. The detailed vertical resolution obtained from rockets is vital for atmospheric studies and complements global coverage from satellites.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The reduction in the FY 1975 Budget Estimate for Field Experiment Support was made in order that additional FY 1975 effort in severe storm research

might be undertaken. Previously planned activities in Field Experiment Support affected by the reduction have been deferred until FY 1976.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Development of an improved meteorological rocket system will be completed in FY 1975. This system will reach 80 km instead of the existing 60 km height.

During FY 1976 and the transition period, approximately 65 Nike Cajun, Arcas, and boosted dart-type rockets will be launched at widely separated sites to obtain information about the distribution and concentrations of minor stratospheric constituents. About 38 optical ozone soundings will be made to obtain the vertical profile of ozone during daylight and about 8 chemi-luminescent soundings will be made to obtain the vertical profiles of ozone during night time. Stratospheric ozone is critical because it shields the earth from the dangerous ultraviolet rays emanating from the sun.

Two nitric oxide soundings will be made to obtain the vertical profile of nitric oxide and one payload will be flown to 40 km on a balloon to measure solar spectral irradiance profiles. Nitric oxide is of interest because it is a stratospheric contaminant produced by high-flying aircraft.

Three payloads will be launched to determine the Bremstrahlung ozone source. Additionally, in accordance with the US/USSR Agreement establishing an Eastern and Western Hemispheric meridional network of meteorological rocket stations, a total of approximately 300 improved rockets that will reach about 80 km will be launched from Wallops Flight Center and foreign sites. Wallops Flight Center's field experiment support will provide for an aircraft to fly range safety surveillance. Cooperative assistance will also be provided for a new rocket sounding site in Brazil.

Severe Storm Observations Satellite (STORMSAT)
Definition Studies

	1975			
	Budget	Current		Transition
1974	Estimate	Estimate	1976	Period
	(Thousands of Dollars)			
---	---	---	$1,500	$300

OBJECTIVES AND STATUS:

In a typical year, the U.S. mainland experiences eight tropical storms, 600 tornadoes, 600 damaging hailstorms, and 800 severe local windstorms, with the attendant property damage and loss of life. The capability to selectively measure the atmospheric structure on a nearly continuous

basis along with improvements data handling and analysis will provide the research tools which will lead to significant improvements in severe storm forecasting. The objective of the STORMSAT definition studies is to define the needed characteristics of an advanced sensing device termed the Advanced Atmospheric Sounding and Imaging Radiometer (AASIR) for the observation of the short-lived and violent meteorological features which describe and are associated with severe storms.

The STORMSAT is planned to be positioned at geosynchronous altitude at a longitude which passes through the middle of the North American continent. It will complement the existing spin-stabilized satellites of the Synchronous Meteorological Satellite (SMS)/Geostationary Operational Environmental Satelite (GOES) system by providing data of higher spatial and temporal resolution required to detect severe storms over the continental U.S. The STORMSAT will have three-axis stabilization which will enable the satellite sensors to be pointed continuously at the earth. The AASIR will be a second generation very high resolution radiometer, and will utilize the telescope and selected other systems of the SMS/GOES Visible and Infrared Spin-Scan Radiometer (VISSR) and the VISSR Atmospheric Sounder (VAS) currently under development in the Advanced Applications Flight Experiments program.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Definition studies conducted in FY 1976 and the transition period will evaluate the trade-offs associated with sensor integration, the spacecraft characteristics, desired orbital characteristics, appropriate launch vehicle, and the data handling requirements. The results of these studies will provide the necessary information prior to proceeding with the implementation phase. If undertaken as an FY 1977 new initiative, the launch of STORMSAT could occur in 1980.

Advanced Techniques in Observing and Forecasting

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$4,828	$5,000	$5,400	$5,700	$2,400

OBJECTIVES AND STATUS:

The objectives of this program are the establishment of the physical principles upon which remote sensors can be developed and employed, the development of the techniques for the acquisition of environmental data by remote sensors, and the application of the data to the definition of the earth's atmosphere and the prediction of its changes. This effort provides the interconnecting bridge between scientific investigations and the design and development of engineering hardware for both research and operational uses in meteorology.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The increase in the FY 1975 Budget Estimate resulted from an augmentation of severe storm research, especially for increased aircraft surveillance of areas of extreme atmospheric turbulence.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In FY 1975, research activities are being focused on the development of advanced techniques for observing and forecasting severe local storms, particularly thunderstorms, tornados, and hurricanes, and on the problems of climate variability. Efforts are also directed toward the application of advanced techniques in infrared and microwave sounding of atmospheric moisture profiles to improve understanding of the behavior of the earth's atmosphere. Research will continue on the physical processes of radiative transfer as they affect the earth's heat budget and the quality of the environment.

During FY 1976 and the transition period, the severe storms research program will include detailed studies of geostationary satellite photographs, of possible improvements to satellite systems, special aircraft overflights of severe storms, and joint studies with NOAA, other Government agencies, and university scientists. Research emphasis will also be placed on small scale, short-lived but destructive weather phenomena, including not only thunderstorms, tornados and hurricanes, but also flash floods, heavy frosts and winter storms. This program will expand the current state of knowledge about severe storms to aid in the development of systems to detect, monitor, and forecast severe storms.

New investigations will also be initiated to improve numerical weather prediction, using the Nimbus-series satellites' measurements of atmospheric composition, solar radiation, sea-surface temperature, and thermal structure of the earth's atmosphere. To make optimum use of these important descriptive data, improved techniques are being developed for their processing, display, and application to numerical models. Climate research will be focused on studying the relatively slow changes of global weather or climate that bring about large scale/long-term changes reflected in droughts, series of severe or mild winters, monsoon patterns, and motion of polar ice. Concurrently, research is being conducted to adapt and refine short-term numerical prediction models to accept long-term parameters related to the laws of climatic behavior.

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Cloud Imaging from Synchronous Satellites (SMS- 1 and B)

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Spacecraft	$8,546	$1,400	$1,225	---	---
Sensors	505	---	475	---	---
Ground station support	949	---	400	---	---
Total	$10,000	$1,400	$2,100	---	---
Delta (Launch vehicle procurement program)	($5,600)	(---)	(---)	(---)	(---)

OBJECTIVES AND STATUS:

The objectives of the Synchronous Meteorological Satellite (SMS) program are to demonstrate a prototype operational system which will meet the requirements of the National Oceanic and Atmospheric Administration (NOAA) to: (1) permit continuous observation of major weather systems routinely, thus enhancing the ability to predict and locate severe short-lived storms; (2) derive important wind field data over large areas and in much less time than heretofore possible; and (3) provide a capability for rapid dissemination of processed meteorological data to local meteorologists.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The increase in the FY 1975 Budget Estimate was required to correct technical problems in the SMS-B spacecraft communications and sensor systems, and in the development of the trilateration ground system. Also, increased funding was necessary to cover increases in launch and post-launch support as a result of the delay in the launch date of SMS-B from mid-1974 to January 1975.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

No funds are requested for FY 1976 and the transition period. The NOAA will fund the operations of SMS-1 and SMS-B, as well as subsequent satellites of this series.

POLLUTION MONITORING

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Oceanographic and air pollution observing satellite (Nimbus-G)	$8,800	$27,000	$19,000	$15,000	$7,500
Sensor definition and feasibility evaluations, modeling, operational methodology	2,796	2,800	3,400	4,200	1,200
Total	$11,596	$29,800	$22,400	$19,200	$8,700

The primary objective of the Pollution Monitoring program is the development and demonstration of systems capable of identifying and measuring pollutants in the air and water on global and regional scales.

For the atmosphere, this effort will focus on providing the technology needed to establish a baseline on the levels and distribution of natural and man-made pollutants. It is presently thought that a disturbance of the atmosphere by aerospace vehicles, aerosol sprays, refrigerants, or other sources of thermal or chemical pollutants could eventually cause a reduction in stratospheric ozone--a trace gas that shields the biosphere from harmful ultraviolet radiation. Thus, global data on atmospheric pollutants and natural constituents are needed to determine both their change and the rate of that change. Data of this type is now being obtained from instruments flown on aircraft; and development of the needed global space observation capability has been initiated. In the area of water quality, a capability is being developed in the area of remote sensing of chlorophyll, pollution, sediment and salinity. Development of instrumentation to provide data on these parameters is now underway.

The Oceanographic and Air Pollution Observing Satellite (Nimbus-G) currently under development and scheduled for launch in CY 1978, will be a major step forward in providing important global data on the pollutants and constituents of the atmosphere and on surface parameters of the ocean. In addition, the Stratospheric Aerosol and Gas Experiment (funded under the Applications Explorer program) will provide complementary data on atmospheric particles. This small satellite will be placed in an orbit designed to permit mapping stratospheric particulates over regions of the globe not covered by Nimbus-G. When the data from both satellites is combined, stratospheric particulates can be mapped over nearly all of the earth.

Air Pollution and Oceanographic Observing Satellite (NIMBUS-G)

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Spacecraft.....	$74	$11,800	$10,700	$5,500	$2,500
Sensors and data analysis	8,726	14,700	8,000	7,900	4,100
Ground support.....	---	500	300	1,600	900
Total.....	$8,800	$27,000	$19,000	$15,000	$7,500
Delta (Launch vehicle procurement program)...	(---)	($400)	($1,400)	($3.500)	(---)

OBJECTIVES AND STATUS:

The major objectives of the Oceanographic and Air Pollution Observing Satellite (Nimbus-G) are the acquisition of environmental data on a global basis which is integrated, repetitive, and synoptic. This data is required for atmospheric pollution and oceanography investigations and will be applied to studies in the concentration, distribution, and time variation of the atmospheric and oceanic contaminants.

Five sensors on Nimbus-G will provide measurements of important atmospheric gaseous and particulate pollutants. The gases to be measured are directly related to such large-scale pollution problems as the use of fossil fuels and the effect of high altitude aircraft operations on the stratosphere. The gases to be measured include ozone, methane, nitric acid, nitric oxide, nitrogen dioxide, carbon monoxide, carbon dioxide, water vapor, sulfur dioxide and ammonia. In addition, concentrations of particulates will be studied to measure their long-term effects on climate; another experiment will obtain heat budget measurements of the earth for the establishment of thermal baselines and to detect changes, particularly those attributable to the activities of man. The other three instruments will obtain data for use in oceanography investigations to support studies in ocean food sources and surveys of ocean pollution, and to improve our knowledge of the interactions between the ocean and the atmosphere. The measurements to be obtained are: high-accuracy sea-surface temperature measurements; high spatial resolution ocean color measurements near the coastlines (relating to nutrients, pollutants, and salinity); and microwave measurements of the interchange of moisture and energy between the ocean and atmosphere.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The reduction in the FY 1975 Budget Estimate is due to delays in initiation of the sensors development activities, which permitted the reallocation of $5.0 million to the LANDSAT-C development.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

During FY 1975 contracts for the development of all engineering and flight model sensors are to be let. The spacecraft prime contract was awarded in FY 1975; procurement of long-lead time spacecraft hardware and payload interface studies have been initiated.

During FY 1976 and the transition period, the primary effort will be in the spacecraft and sensor development and fabrication areas. The spacecraft detailed design will commence together with initiation of spacecraft fabrication. All instrument engineering models will be built and tested, and fabrication of the protoflight models will be nearing completion. Fabrication of the flight models will be well underway by late FY 1976. The Nimbus Observatory Processing System for Nimbus-G will be designed and hardware delivery will begin. In addition, software necessary for computer programs and mission operations planning will be initiated.

Sensor Definition and Feasibility Evaluations, Modeling, Operational Methodology

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$2,796	$2,800	$3,400	$4,200	$1,200

OBJECTIVES AND STATUS:

The objective of this effort is to apply aerospace technology to the assessment of environmental quality and to the evaluation of candidate strategies for enhancing air and water quality. This requires study of the unique physical and chemical properties of pollutants and the use of mathematical models to determine how accurately and how frequently such pollutants must be measured. From this information, instruments are developed, demonstrated, and data obtained to validate and update the models. This leads to selection of sensors for monitoring systems and development of prototype systems, frequently in cooperative programs with other Government agencies.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The increase in the FY 1975 Budget Estimate results from an augmentation of the effort in stratospheric research; the additional effort is required to initiate modeling activities on the effects of pollution on upper atmospheric constituents, particulary ozone, and to increase the data analysis activities related to airborne research flights.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Fiscal Year 1975 activities include, for air pollution, laboratory investigations on the properties of some key gases; in addition, other atmospheric constituents have been identified for detailed study. The data are used with theoretical models to define appropriate sensing techniques. Techniques are also being developed to allow separation of the effects of atmospheric particles from those gases. Existing engineering models of remote sensors for atmospheric constituents are being tested in aircraft.

Fiscal Year 1975 efforts in the remote sensing of water quality involved laboratory measurements of the optical characteristics of water containing known pollutants. The measurements were made to permit judgments concerning ways to discriminate between pollutants and the necessary sensor technology to obtain the required measurements. In addition, plans were developed for a coordinated NASA Stratospheric Research program, for a cooperative program in the Great Lakes Region with the Environmental Protection Agency (EPA) and in the New York Bight with the National Oceanic and Atmospheric Administration (NOAA). Implementation of the first two is expected in late FY 1975.

During FY 1976 and the transition period, increased emphasis on global monitoring of the stratosphere will require coordinated programs in: sensor development; fundamental physical and chemical processes; modeling for establishing sensor requirements (to aid in data analysis and to assess the impact of aerospace operations); and measurements to establish global baselines. There will be a continuation in the activity for remote sensing of water quality. In addition, it is expected that the cooperative effort with NOAA in the New York Bight region (Marine Ecosystem Analysis program) will be initiated.

EARTH RESOURCES SURVEY

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)				
Earth resources technology satellite (LANDSAT 1 and B).....	$16,400	$11,100	$8,700	$5,300	---
Multispectral scanner 5th band development..	1,000	4,000	4,000	2,000	---
Earth resources technology satellite (LANDSAT-C).....	---	---	5,000	11,000	$3,500
Applications airborne research program.....	16,600	17,300	15,500	13,330	3,600

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Earth resource experiment package (EREP) investigations.....	($3,200)	$3,800	$2,500	$1,500	---
Applications systems verification tests (ASVT).....	---	---	(7,900)	9,300	$2,900
Data interpretation techniques, special investigations and data analyses.....	13,488	22,400	24,900	19,600	5,000
Total.....	$47,488	$58,600	$60,600	$62,030	$15,000

The very serious global energy and food crises are reminders that better information about the planet we inhabit is needed. Better geological data are required for energy exploration. More rapid and accurate agricultural information is needed for crop assessment. What is clearly developing is a need to manage resources and the environment in order to cope with global problems. Satellites containing remote sensors are one of the few means available to provide objective information on a worldwide basis. They have the unique capability of passing over every point on the earth repetitively and acquiring data of value to resource managers.

The Earth Resources Survey program has as its objective the development of the technology for acquiring and interpreting remotely sensed information necessary for large-scale management purposes. A sizeable commitment has already been made to obtain and use satellite acquired earth resources data. Enthusiastic cooperation of government agencies at Federal, State, and local levels as well as in the private sector and in the international arena has developed, and practical applications of remotely sensed data have been demonstrated.

Accomplishments to date include the successful operation of the first Earth Resources Technology Satellite, LANDSAT-1, exceeding two and a half years in orbit; the flight of the Earth Resources Experiment Package (EREP) on Skylab, and the successful launch of the second experimental earth resources satellite, LANDSAT-B. Data from these missions has successfully demonstrated the capabilities of space-based remote sensing data and its application to both immediate and long-range user community requirements. These include such areas as the identification of potential oil bearing formations in Alaska, the computer classification of crop types in Nebraska with better than 90 percent accuracy and the assessment of flood extent and damage by the Missouri and Mississippi Rivers. To demonstrate

the practical values of LANDSAT data for user activities in land use, geological exploration, coastal zone monitoring, world crop surveys, flood mapping and others, an Applications Systems Verification Test program was initiated.

The Application Systems Verification Test program will take the most promising areas of research identified in the LANDSAT-1 program and, in concert with user agencies and resource managers, define, demonstrate and document the application of remote sensing systems on a simulated operational basis. One example is the Large Area Crop Inventory Experiment, being undertaken with the U.S. Department of Agriculture and the National Oceanic and Atmospheric Administration. Because of the increased demand for digital data for these applications, an increased capacity to produce radiometrically and geometrically corrected computer tapes is being established.

Additional data of value for investigations in earth resources will be obtained by the Heat Capacity Mapping Mission. The Heat Capacity Mapping Mission is the first Applications Explorer Mission, and is separately funded under the Applications Explorer Missions program. This satellite will fly the Surface Composition Mapping Radiometer, which will obtain data of sufficient quality to produce thermal maps for discrimination of rock types and mineral resource location.

Earth Resources Technology Satellite (LANDSAT 1 and B)

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Spacecraft	$4,917	$3,200	$3,394	$1,100	---
Sensors	2,647	---	359	---	---
Ground operations	1,381	2,300	2,637	1,900	---
Investigations	7,455	5,600	2,310	2,300	---
Total	$16,400	$11,100	$8,700	$5,300	---
Delta (Launch vehicle procurement program)	($3,500)	($1,100)	($1,100)	(---)	(---)

OBJECTIVES AND STATUS:

The objective of the Earth Resources Technology Satellites, LANDSAT-1 and -B, is to frequently and repetitively obtain large-scale images of the earth for the purpose of developing improved means to manage many dynamic resources on a local, regional, and national basis, and as necessary on a worldwide basis. The current program activity is directed

to the demonstration of useful applications of LANDSAT data to significant problems in agriculture, geology, hydrology, ecology, cartography, and oceanography.

The launch of LANDSAT-1 in July 1972 initiated the program of repetitive observations of earth resources from space. The Departments of Agriculture, Interior, Commerce, and Defense actively participated with NASA in planning the overall program as well as by conducting investigations relating to their areas of special interest. As these investigations are nearing their completion, 93 follow-on investigations, consisting more of research teams than individuals, have been selected to conduct more in-depth applications of LANDSAT data.

The multispectral scanner data has continued to be of exceptional technical quality since launch. It has proven to be extremely versatile and valuable for producing map-like images which exceed National Map Accuracy standards at the 1:1,000,000 scale and for its capability to be automatically analyzed by high-speed digital computers. A wide range of crops, land use categories, and important surface features have been automatically classified by using this computer processing technique.

Previously unrecognized major geologic faults related to earthquake epicenters have been detected by LANDSAT-1. Mapping of floods, snow covered areas, and regional water resources has been accomplished. Pollution plumes, strip mining, and reclamation efforts have also been monitored. Observations of coastal water turbidity has been correlated with the location of menhaden fish schools; and sea ice affecting ocean shipping has been mapped and its movement plotted.

The continuity of data provided by LANDSAT-B will broaden the range of user activities in the Federal Government and the overall civilian sector. The additional data will increase the accuracy of the assessments of such phenomena as crops, water, and environmental conditions subject to seasonal effects.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The overall reduction in the FY 1975 Budget Estimate is due to longer than anticipated negotiations of contracts for the follow-on investigations. Minor increases in the spacecraft, sensors, and ground operations activities have resulted from minor technical problems encountered and an increase in the amount of contractor support required.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

The FY 1975 effort includes continued operations of the LANDSAT-1, support of ongoing and follow-on investigations, and the launch and initial period of LANDSAT-B operations. Selective operation of both LANDSAT-1 and LANDSAT-B is being conducted in order to test the value of more frequent observations

of rapidly changing phenomena, such as crop growth, rangeland grass buildup, and snow melt. The NASA data processing facility is being augmented to provide an increased capacity for producing tape products to meet user requirements. In FY 1975 this augmentation is providing a capability to produce about ten times as many computer compatible tapes as were previously attainable; late in 1976 a capability will be developed to deliver all data received as geometrically accurate computer compatible tapes.

The primary effort in FY 1976 and the transition period will be directed toward the flight operations of the LANDSAT's and continuation of the approximately 100 follow-on investigations. Flight operations will include mission planning and the operations of the spacecraft control center on a 24 hour-per-day basis.

Multispectral Scanner - Fifth Band Development

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$1,000	$4,000	$4,000	$2,000	---

OBJECTIVES AND STATUS:

The objective of adding a thermal channel to the LANDSAT's primary sensor, the Multispectral Scanner, is to provide a measurement of radiation in the thermal spectrum in addition to the four channels in the visible and near-infrared portions of the spectrum.

The thermal infrared channel will provide the capability required to observe resources and conditions characterized by temperature differences, especially those which require intercomparison with simultaneous observations at visible or near-infrared wavelengths. At the Laboratory for Applications of Remote Sensing at Purdue University, it has been shown that the addition of a thermal channel to the existing four channels of the Multispectral Scanner significantly increases the ability to classify agricultural products. Such intercomparisons also indicate high utility for identification of forest types; mapping and measuring thermal pollution of large lakes, bays, and estuaries; and providing information about moisture content of soils. Observations of ocean temperature differences will also provide data needed for investigations of shoreline changes, fisheries, and coastal circulation patterns.

The need for thermal infrared observations to correlate with those at visible and near-infrared wavelengths was recognized early in the planning of the Earth Resources Technology Satellite. Work was started to develop the hardware but technical difficulties in designing an apparatus to cool the

thermal infrared detector prevented inclusion on LANDSAT-1 or LANDSAT-B. It was decided nonetheless to pursue the development of this important sensor in order to be assured that the thermal channel capability on a future earth resources satellite was technically feasible. It will now be incorporated on LANDSAT-C.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATE:

In FY 1975, work on the instrument continued and a satisfactory passive radiative cooler was built and tested. In FY 1976 and the transition period, fabrication and test of flight components, including the scan mirror assembly, scanner, and data multiplexer, will be completed. These major components and the passive radiative cooler will be integrated into the flight model of the five-channel multispectral scanner; systems test will be conducted; and the flight model will be delivered to the LANDSAT-C prime contractor for integration into the spacecraft.

Earth Resources Technology Satellite (LANDSAT-C)

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
			(Thousands of Dollars)		
Spacecraft	---	---	$4,000	$9,000	$3,200
Sensors	---	---	1,000	1,500	200
Ground operations	---	---	---	500	100
Total	---	---	$5,000	$11,000	$3,500
Delta (Launch vehicle procurement program)	(---)	(---)	(---)	($3,000)	(---)

OBJECTIVES AND STATUS:

The principal objective of LANDSAT-C is to continue the research and development of medium-resolution, multispectral remote sensing systems to be used from space for global data acquisition. The performance of the instrumentation will be significantly improved over the sensors used on LANDSAT-1 and -B. These performance improvements will permit more accurate assessments in a wide range of applications in agriculture, the environment, hydrology, and mineral and energy resources.

LANDSAT-C will include both an improved Multispectral Scanner and an improved Return Beam Vidicon camera system. The Multispectral Scanner (MSS) will have a thermal channel added to the existing four channel instrument. This thermal infrared channel will enable the observation of phenomena characterized by temperature. The new data obtained and the related

investigations could be invaluable in the areas of crop forecasting, measurements of thermal pollution of water resources, and improved reliability of classifications of hydrological and geological phenomena. This five-channel MSS has been separately developed and funded. The modifications to the Return Beam Vidicon (RBV) camera system will allow the spatial resolution to be improved by a factor of two, thus providing greater accuracy in locating, identifying, and mapping surface features.

The data which will be returned by LANDSAT-C will provide a basis for comparisons showing general trends and changes as well as the degradation or improvement of environmental and ecological quality. LANDSAT-C will also provide the continuity of data analysis effort necessary to long-range user community requirements. Current planning is for a launch in the third quarter of 1977.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

A third Earth Resources Technology Satellite received Congressional authorization in FY 1975; although funds were not specifically appropriated for the program, both House and Senate Appropriation Committees urged NASA to reprogram the necessary funds within the total resources made available to the Agency. The Administration has decided to proceed with the program and consequently $5.0 million was reallocated as indicated.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In FY 1975, the effort on the spacecraft will primarily be for procurement of long-lead items essential to meet a CY 1977 launch date. These include the Data Collection System, the Versatile Information Processor (Data formatter), solar arrays, command clock and piece parts for the spacecraft structure, electrical harnesses and telemetry modules. Where practical, these procurements will be made in concert with the Nimbus-G program to reduce overall costs.

Procurement of long-lead components for the Return Beam Vidicon Camera (RBV) system are also required. These include electronic parts, base plate castings, on-off transformer, etc. A design study will be conducted to determine the remaining long lead items for the RBV, such as lenses and the selection and test of vidicons essential for the required resolution of the RBV system for LANDSAT-C. The Multispectral Scanner effort is being funded separately.

During FY 1976 and the transition period, the spacecraft design will be completed and fabrication will be initiated. The Multispectral Scanner will complete its development, assembly and test, and will be ready for integration into the spacecraft. The Return Beam Vidicon cameras will be designed, assembled, and will undergo subsystem tests. Delivery of the

RBV's is anticipated early in 1977. In addition, the necessary modifications to the ground data processing facilities to accommodate the sensor changes will be initiated, along with the detailed ground operations planning and the software.

Applications Airborne Research Program

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Applications airborne research	$14,800	$16,400	$14,600	$12,630	$3,600
CV 990 replacement	1,800	900	900	700	---
Total	$16,600	$17,300	$15,500	$13,330	$3,600

OBJECTIVES AND STATUS:

The objectives of the Applications Airborne Research program are to acquire remote sensing data necessary to support the development, demonstration and evaluation of remote sensing instruments and interpretive techniques to provide for satellite underflights for verifying space acquired data, and to conduct in situ data acquisition flights in support of meteorological and environmental quality programs.

This program continues to serve as a national airborne remote sensing facility and is being used to support the investigative programs of NASA and several other agencies. The release of a substantial portion of the total aircraft remote sensing capability from the extensive Earth Resources Technology Satellite and Skylab underflight effort has permitted NASA to focus on a much wider range of applications related research tasks. These include meteorology, environmental quality communications and earth and ocean physics.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The reduction in the FY 1975 Budget Estimate is due to a decision to reallocate funds from this program element to initiate the Large Area Crop Inventory program. Reduced data analysis requirements and reductions made in the planned number of flight hours permitted the reallocation to be made.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

For the Earth Resources Survey program in 1975, the aircraft program will provide support for several ongoing and planned Applications System Verification Tests including the Large Area Crop Inventory Experiment being

conducted in cooperation with the USDA and the Great Lakes ice monitoring project to be demonstrated by Lewis Research Center in cooperation with the U.S. Coast Guard.

Continuing spacecraft underflight activity is also anticipated in conjunction with evolving projects such as the LANDSAT follow-on investigations program and Nimbus-G, but at a much reduced level from that committed to LANDSAT-1 and Skylab during the past two years.

During FY 1976 and the transition period, severe storm research and environmental quality will be supported by numerous aircraft efforts which are characterized by stratospheric sampling flights with the U-2's and thermal mapping with high altitude aircraft in relation to Nimbus-G studies. Several multispectral scanner flights are also planned in conjunction with the Environmental Protection Agency to support their efforts in water quality research. Sensor definition flights will focus on the development of instruments for Nimbus-G, the Ocean Dynamics Satellite (SEASAT) and the Heat Capacity Mapping Mission.

Modifications to the replacement CV 990 aircraft will be completed to restore the full capability of the research facility lost in an accident in April 1973. These include the integration of new avionics systems and the addition of experiment support systems and sensor ports. These modifications were scheduled for FY 1976 in order to have the aircraft available for the recently completed GARP Atlantic Tropical Experiment expedition (GATE).

Upcoming expeditions for the CV 990 now under review include the Arctic Ice Dynamics Experiment, Severe Environmental Storms and Meso Scale Experiment and Project Stormfury which deals with hurricane seedings to modify high-energy patterns.

Earth Resources Experiment Package (EREP) Investigations

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
($3,200)	$3,800	$2,500	$1,500	---

OBJECTIVES AND STATUS:

The objectives of the Earth Resources Experiment Package (EREP) investigations program are to use the data obtained from the EREP on Skylab to conduct studies in earth resources disciplines and to provide the information needed to complete the definition of the second generation of remote sensing instruments (being developed in other earth observation projects).

The EREP was developed under the Skylab program and was launched as an integral part of the Skylab Workshop in May 1973. The EREP included photographic cameras, a visible and infrared spectrometer, a thirteen-band multispectral scanner, active and passive microwave instruments, a control panel and magnetic tape recorders. During the three subsequent Skylab missions over 40,000 photographs and 240,000 feet of recorded observations of the earth were acquired by the Skylab crews.

Initial study results have provided new information on the detection and mapping of snow, on the usefulness of microwave techniques for soil moisture measurements, on geoidal variations associated with subsurface ocean topography, on the determination of local wind speeds over ocean areas, and on mesoscale eddies associated with ocean current systems. Other results are providing quantitative evaluation of the significance of specific spectral bands and spatial resolution not available in the LANDSAT system to crop inventories, land use determinations, and many other applications.

The acquisition and processing of EREP data and the initial support through FY 1974 of the data analysis was funded by the Office of Manned Space Flight. The Office of Applications is responsible for the selection and management of the investigators and investigations and for funding completion of the studies.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The reduction in funding requirements for FY 1975 results from the deletion of plans to initiate new data use investigations as part of the EREP program. EREP data are available through the Federal Data Centers and will be used, as necessary, to support studies funded as part of the Supporting Research and Technology program.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

In FY 1975 the processing and dissemination of EREP data to Principal Investigators and other users will be completed. Approximately one fourth of the 140 EREP investigations are scheduled to be completed. These investigations include studies of land use, water resources, cartography, agriculture, geology, geodesy, and coastal zones.

During FY 1976 and the transition period, the remainder of the 140 investigations will be completed. The results of the EREP investigations will be published in individual reports and will be summarized in a report which will include an assessment of the relative value of spatial and spectral resolution, additional spectral bands, and microwave techniques in the various application disciplines.

Application Systems Verification Tests (ASVT)

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)		
---	---	($7,900)	$9,300	$2,900

OBJECTIVES AND STATUS:

The objective of the Application Systems Verification Test (ASVT) program is to take the most promising areas of research obtained from the LANDSAT investigation program and--through a concerted effort with user agencies and resources managers--to define, demonstrate and document the practical capability of remote-sensing-based information systems to make substantial contributions in these areas. The results should allow cognizant resource managers to make decisions on whether or not to implement remote-sensing-based systems operationally. If so, these activities will facilitate the transfer of demonstrated capabilities to the appropriate user organizations by providing the necessary information on organization, costs and procedures.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

Some ASVT projects were initiated as a separate effort in FY 1975 with funding from the Earth Resources Survey Data Interpretation Techniques, Special Investigations and Data Analyses area. The program is identified in FY 1976 as a separate budget item.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

One of the projects under the Applications Systems Verification Test program is the Large Area Crop Inventory Experiment (LACIE). LACIE has been initiated as a cooperative effort with the Department of Agriculture and the National Oceanic and Atmospheric Administration (NOAA). The principal objective during FY 1975 and FY 1976 is to determine whether remote sensing data acquired by LANDSAT-1 and -B and analyzed with the aid of computers can improve the timeliness and accuracy of major crop forecasts first for North America and then for other regions. Wheat will be the test crop for the experiment. If successful, the techniques and approaches developed will be made available for expanded international coverage and for incorporation into routine USDA agriculture forecasting. Another project is a joint Lake Ice program involving NASA, the United States Coast Guard (USCG) and NOAA. The objective of this project is to develop an aircraft-data-based, rapid all-weather system to provide accurate ice distribution maps to ships in order to expand the shipping season on the Great Lakes. In FY 1975 the system will be developed and an initial field

demonstration with the USCG and NOAA will be conducted. The FY 1976 objective will be to conduct a complete demonstration over the full 1975 ice season and transfer the technology to the users for operational use.

Several other ASVT projects have been undertaken in cooperative efforts with a number of State and regional agencies. These projects include: an automated natural resources system for the State of Mississippi; an automated environmental system for updating the Corps of Engineers basic environmental atlas of a predominantly wetlands region of southern Louisiana; a project to accurately monitor snow accumulation and spring run-off for water management purposes in Arizona, California, Colorado, and the Pacific Northwest; and a project using advanced data processing techniques to generate information on land use changes, soil moisture, snow cover and other environmental parameters required for large area water district management.

For all of the ASVT projects, the objective will be to define the management structure and the operation of the system as well as ways in which remotely sensed data would be processed and utilized by the cooperating user agencies.

During FY 1976 and the transition period, the ASVT program will continue selected demonstrations of the application of remotely sensed data to routine operational use; as the application is proven and reaches mature status, the technology will be transferred to the using agencies. In the Large Area Crop Inventory Experiment (LACIE), aggregate production estimates based on sample areas and yield data will be developed; modifications will be made as needed to the system to improve operations. The Lake Ice program will conduct a complete demonstration over the full ice season and then will transfer the technology to the users for operational use. Other ASVT's mentioned above will also be developed to the point of being ready for transfer to user organizations.

Data Interpretation Techniques, Special Investigations and Data Analyses

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Data interpretation techniques, special investigations and data analyses	$13,488	$13,000	$15,500	$11,600	$3,000
Earth resources survey data processing, evaluation and analysis, photographic services, related supplies, and equipment.....	(9,500)	9,400	9,400	8,000	2,000
Total.....	$13,488	$22,400	$24,900	$19,600	$5,000

RD 7-34

OBJECTIVES AND STATUS:

The objectives of this effort are to conduct initial research on promising advanced remote sensing systems, to develop the technology to extract the maximum amount of information possible from available remote sensing data. Another objective is to identify promising areas of application on which special effort should be placed in Application Systems Verification Tests (ASVT's). These research tasks provide the foundation and direction for for future development of the Earth Resources Survey program. It is here that the new technology is developed to maintain the U.S. as the recognized world leader in the use of remote sensing data for earth resources investigations.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The increase in the FY 1975 Budget Estimate was required to provide greater support to the Applications Systems Verification Tests (ASVT) activity; notably the Large Area Crop Investigation Experiment (LACIE).

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In FY 1975 research and development was concentrated in four major areas: the initial development of new imaging systems including microwave sensors that have all-weather sensing capabilities; the development of advanced data handling and processing techniques and equipment; the improvement of data interpretation and classification; and the demonstration, documentation, and effectiveness analysis of remote sensing techniques to meet the earth resources information requirements of users. In addition, work continued on those design studies for the development of a Thematic Mapper with a resolution about a factor of two better than the LANDSAT or EREP Multispectral Scanners.

In FY 1975 emphasis was also shifted away from conducting a relatively large number of small exploratory experiments toward conducting a lesser number of larger scale tests of potential remote sensing information systems under realistic conditions. Several Application Systems Verification Tests (ASVT) were initiated in 1975.

In FY 1976 and during the transition period, research will continue on quantify ng remote sensing data and presenting the data in a format that is most understandable and useful to resource managers. Specifically, work will continue on developing techniques to increase identification and measurement accuracies in agriculture through temporal analyses, crop calendars, and effects of varying sun angle as well as techniques to help indicate crop vigor and forecast yield. Work will also continue on improving remote sensing capabilities for soil moisture detection and measurement and to validate and demonstrate advanced remote sensing techniques in forestry applications. In mineral resources, efforts will concentrate on further refinement of digital

enhancement techniques for identifying and determining the significance of surface alterations caused by underlying mineral and petroleum deposits, on the development of spatial filtering techniques, and on evaluating the utility of infrared sensors. In land use, work will continue on developing techniques for automatic classification and change detection. Development of snow survey and watershed models required for the utilization of remote sensing data will be pursued in the water resources area while further work will be done to develop quantitative measures of chlorophyll, salinity and surface temperatures in marine resources. In technology development, emphasis will be in the development of automatic data processing techniques to improve accuracies and the development of methods for remote sensing signature extension with the goal of minimizing the need for ground truth in data analysis. In the area of new flight instruments, selection and award of a contract for detailed design of the Thematic Mapper will be made, and basic technology work will continue on microwave instruments to overcome cloud cover limitations.

EARTH AND OCEAN PHYSICS APPLICATIONS PROGRAM (EOPAP)

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Laser geodynamics satellite (LAGEOS)	$1,300	$2,300	$2,300	$1,000	$300
Ocean dynamics satellite (SEASAT-A)	---	8,000	8,000	17,000	5,000
Tectonic plate motion	---	2,000	1,900	2,600	800
Measurement systems, forecasting techniques and modeling/advanced studies	3,000	2,600	3,100	3,100	900
Experiment data analysis	2,700	2,700	2,700	2,700	800
Geodynamic experimental ocean satellite (GEOS-C)	3,400	900	900	---	---
Total	$10,400	$18,500	$18,900	$26,400	$7,800

The primary objective of the Earth and Ocean Physics Applications program (EOPAP) is to provide the focus for those applications which make use of space or space-derived techniques for monitoring numerous ocean phenomena, such as sea state, currents, surface winds, and general ocean circulation patterns on a global basis, as well as for very precise monitoring of the earth's crustal motion, polar movement, and changes in rotation rate.

Program activities are directed toward development and validation of: (1) means for predicting the general ocean circulation and surface currents, and their transportation of mass, heat, and nutrients; (2) methods for synoptic monitoring and predicting of transient ocean surface phenomena, including the magnitudes and geographical distributions of sea state, storm surges, swell, surface winds, etc., with emphasis on identifying existing and potential hazards; (3) methods leading to earthquake hazard assessment and alleviation models which can predict probable time, location, and intensity of earthquakes; and (4) expansion of our knowledge about the global geoid, of the geomagnetic field, and the geodesy of inaccessible areas such as the ocean floors. To accomplish these objectives, both satellite and surface-based measurements are required. Each of these projects is discussed below.

Laser Geodynamic Satellite (LAGEOS)

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
			(Thousands of Dollars)		
Spacecraft.....	$830	$1,455	$1,455	---	---
Ground operations.....	470	845	845	$1,000	$300
Total.....	$1,300	$2,300	$2,300	$1,000	$300
Delta (Launch vehicle procurement program)	($3,000)	($1,600)	($1,300)	(---)	(---)

OBJECTIVES AND STATUS:

The objective of the LAGEOS program is to provide the capability for making extremely accurate determinations of the earth's crustal and rotational motions by means of laser tracking techniques. It will be a major advance over other current capabilities in this respect. LAGEOS will be employed to observe a number of phenomena associated with earthquakes, including fault motion; regional strain fields; tectonic plate motion; earth rotation; polar motion; and solid earth tides, as well as contributing to other efforts such as the EOPAP ocean dynamics program.

The LAGEOS program includes the building and launching of a very accurate reference satellite incorporating precision retroreflectors, the development and use of accurate laser ground tracking stations, and the application of the laser data in connection with the generating of models of the earth's crustal and dynamic motions.

The satellite will be a dense sphere covered with 426 laser retroreflectors. It will have a diameter of about 0.6 meters (2 feet), and will weigh 411 kg (906 pounds). Its array of corner reflectors will be especially designed to

minimize errors associated with the reflection of the short laser pulses. It will be launched into a 5,900 km circular orbit at 110° inclination. Its altitude will be high enough to lessen the effect on the orbit due to perturbations in the earth's gravitational field. It will have a mass-to-area ratio great enough to markedly diminish the effects on the orbit caused by variations in the pressure of radiation from the sun and the earth. The high orbit is well suited to the problem of measuring large scale motions of the earth's crustal plates and the dynamic motions of the earth as a whole as it rotates about its polar axis.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

The satellite qualification model was built by NASA inhouse at the Marshall Space Flight Center. This was accomplished during the latter part of FY 1974 and early FY 1975. Since the satellite is a very rigid structure of simple design, the qualification model was built to the flight specifications. The qualification tests have now been completed, and the qualification model has been determined to be acceptable for flight, thus deleting the requirement for a separate flight satellite. This results in a programmatic savings and the estimated total runout cost has been reduced by $500,000.

During FY 1976 and the transition period, the last increment of retroreflectors will be delivered. The final assembly of the satellite and optical performance verification will be accomplished. The qualification testing of the satellite-to-launch vehicle interface adapter and satellite ejection mechanism will be completed. The satellite will be integrated with the launch vehicle third and fourth stages and spin-balanced. This assembly will then be integrated with the first and second stages and launched in the first quarter of CY 1976.

Three mobile laser ranging stations and four stationary ones will be available to work with the LAGEOS at the time of launch and additional stations will be available during the next year.

Ocean Dynamics Satellite (SEASAT-A)

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Spacecraft design, development and test...	---	$4,800	$4,800	$7,000	$1,700
Sensor development.....	---	3,200	3,200	10,000	3,300
Total.....	---	$8,000	$8,000	$17,000	$5,000

OBJECTIVES AND STATUS:

The objectives of the Ocean Dynamics Satellite (SEASAT-A) mission include: the demonstration of techniques for global monitoring and mapping of the principal oceanographic phenomena and features; the provision of oceanographic data for both application and scientific users; the creation of a new data base which can be used to extend the scientific understanding of ocean dynamics; and the demonstration of the key features of an operational ocean dynamics monitoring system.

The mission objectives and preliminary design concepts have been developed through the combined efforts of NASA and the user community. Among those participating are some 20 organizations representing other parts of the Government, universities, and maritime interests in the private sector. Included, in particular, are the Departments of Commerce, Defense, and Transportation; Scripps Institute of Oceanography, Woods Hole, and City University of New York; American Institute of Merchant Shipping, American Petroleum Institute, and the Sea Use Council.

The monitoring of the oceans from space by SEASAT-A will provide oceanographers for the first time with the kind of global, synoptic coverage for scientific analysis which have been supplied to meteorologists investigating the atmosphere by TIROS and NIMBUS satellites. The SEASAT-A data will constitute an indispensable base upon which to build new ocean dynamics and improved meteorological forecasting capabilities having major scientific and economic potential.

An existing flight-qualified spacecraft bus will be used to insure program cost efficiencies. This existing bus will be coupled to a sensor module that will contain three new active radar sensors, one existing flight-qualified passive sensor, and associated data handling and power conditioning subsystems. The combined sensor module and existing spacecraft bus will be launched into a 108° inclination circular orbit in 1978.

The three new active radars on SEASAT-A stem from recent NASA research and development activities aimed at evolving sensors suitable for oceanographic data gathering from space. These radar sensors will be complemented by a scanning visible and infrared radiometer originally flown on ITOS, and will be used on SEASAT to provide images of visible and infrared emissions from oceans, coastal and atmospheric features. These SEASAT-A instruments will enable the monitoring of ocean surface conditions to be accomplished with the precision and repetition necessary to make major advances for scientific and user applications including predictions of sea conditions for ship routing, ship design, storm damage avoidance, coastal protection and development, and deep-water port development. Economic benefit studies show that large benefits are associated with the potential capabilities which SEASAT-A will demonstrate.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

During FY 1975, procurement of the spacecraft module, launch vehicle selection, and sensors was finalized, and the detailed design of the sensor module was initiated. During FY 1976 and the transition period, the manufacture and test of the spacecraft bus and the development of the sensors and sensor module will be in process. The sensor preliminary design reviews will be held and the breadboard tests will be completed. Detailed sensor module design will begin following the selection of the spacecraft bus contractor, and the preliminary design review of the module will be completed. The fabrication of a sensor module test model will begin and sufficient testing will be completed to start sensor module fabrication during the transition period.

Tectonic Plate Motion

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
---	$2,000	$1,900	$2,600	$800

OBJECTIVES AND STATUS:

The objective of the Tectonic Plate Motion program is to make key measurements which are expected to contribute significantly to the development of an earthquake prediction capability. These include the measurement of the earth's crustal motion near the earthquake fault zones and the behavior of the earth as a whole as it rotates about its polar axis.

One of the keys to understanding and predicting earthquakes is the ability to measure the movement of the giant tectonic plates which make up the earth's crust. If two adjoining plates are moving at certain places, but are locked elsewhere, then strain is building up. When this strain is released, an earthquake occurs. During the past two years, experimental data have been collected and major progress has been made in measurement systems as well as modeling capabilities, opening up new possibilities for gaining an understanding of the physical processes involved.

The Tectonic Plate Motion program consists of three projects as follows: the San Andreas Fault Experiment (SAFE); the Pacific Plate Motion Experiment (PPME); and Astronomic Radio Interferometer Earth Surveying (ARIES).

The SAFE will demonstrate the feasibility of using laser satellite tracking data to determine surface motions along an active fault over a period of several years.

The PPME will demonstrate the feasibility of using Very Long Baseline Interferometry (VLBI) measurements to determine the relative motions of the Pacific and North American plates.

ARIES will demonstrate the use of VLBI techniques for the measurement of regional scale crustal motion.

During FY 1975 initial observations were made by each of these systems. These observational data have been used to establish positions of the stations involved to accuracies ranging from 15 cm to 5 cm.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

Reduced FY 1975 funding requirements were occasioned by a delay in equipment development for the VLBI activities, particularly PPME.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

During this period of time new equipment will be added to each VLBI station thus improving the system; additional equipment will be evaluated; and a second series of observations and intercomparisions will be completed. These include VLBI triangle closures using stations in Massachusetts, Texas, and California, and the completion of a third station site in Utah for SAFE.

Measurement Systems, Forecasting Techniques, and Modeling

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$3,000	$2,600	$3,100	$3,100	$900

OBJECTIVES AND STATUS:

The objectives of the Measurement Systems and Forecasting Techniques program are to establish a base of analytical and experimental techniques and feasibility investigations which are required for the orderly development and implementation of the Earth and Ocean Physics Applications program.

This effort consists of an integrated series of interconnected tasks including: systems studies for the Earth and Ocean Physics Applications program; design studies of advanced satellite and ground systems; analytical design of Earth and Ocean Physics Applications program missions; preliminary design of experiments (ground-based, aircraft, ships, buoys, and satellites); establishment of measurement requirements; preliminary design

of sensors and subsystems; feasibility experiments on new techniques; intercomparison experiments; analytical models for earthquake hazard assessment and alleviation, ocean currents, ocean dynamics effects, circulation and transport; and development testing of forecasting techniques. Universities, institutions, and other Government agencies will be utilized to perform scientific studies of fundamental phenomena in earth and ocean dynamics. These studies will serve as a basis for establishing detailed requirements for developing experimental and analytical techniques.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The increase in the FY 1975 Budget Estimate was required for studies to better define the specifications of analytical and measurement approaches so as to enhance the orderly development of models, instruments and techniques used in the Earth and Ocean Physics Applications program.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Efforts planned for FY 1976 and the transition period include studies exploring the use of new space techniques, of improvements in present techniques and in more effective use of current systems. Advanced models leading to a better understanding of mechanisms that govern the dynamics of the solid earth and the world's oceans will be developed. Technique, instrument, and model development for supporting the program will be undertaken in order to insure proper program evolution.

Experiment Data Analysis

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition period
	(Thousands of Dollars)			
$2,700	$2,700	$2,700	$2,700	$800

OBJECTIVES AND STATUS:

This program has the following objectives: to analyze all data obtained in the Earth and Ocean Physics Applications program, including data obtained from earth-based experiments and earth/satellite experiments, and to apply these data to particular end objectives, such as mapping and modeling ocean currents; to monitor and forecast sea state, other ocean dynamics effects, and the interactions between ocean and atmosphere; and to assess earthquake hazards.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

During FY 1975 this program provided for the analysis of experiments currently in process to demonstrate the application of precision laser ranging to satellites for the measurement of fault motions. Included in this effort are the analysis and evaluation of new methods of making precision measurements of crustal deformations and earth motions, as well as intercomparisons on basic measurement and analytical techniques, and the analysis and evaluation of related earth dynamics.

In FY 1976 and the transition period, the analysis of data from GEOS-C experiments involving radar altimetry, laser ranging, satellite-to-satellite tracking, and other techniques will be continued. Data from such experiments, will be analyzed to validate and improve scientific and user theories and demonstrate the feasibility and limitations of the various space and ground systems to contribute to the solution of scientific and user problems. Data from intercomparison experiments will be analyzed to establish the relative merits of alternate techniques and the applications of acquired data to the development and assessment of analytical models for ocean currents, transport and circulation, and other earth and ocean dynamics effects.

SPACE PROCESSING

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)				
Ground-based investigations, analyses and studies.....	$2,825	$3,100	$2,900	$3,100	$900
Sounding rocket missions.	---	400	400	600	300
Total.....	$2,825	$3,500	$3,300	$3,700	$1,200

OBJECTIVES AND STATUS:

The objectives of the Space Processing program are to develop applications offered by the unique environment of space for work in materials science and technology and in biological processes; ultimately, this is intended to lead to commercial manufacturing of suitable products in space for use on earth. Under Ground-Based Investigations, Analyses and Studies, work is undertaken both to define the technical and economic potential for useful applications of space processing and to develop the technology required to implement actual space processing operations on future space missions. Under the Sounding Rocket Missions category, funding is provided to carry out sounding rocket flight tests of promising space materials processing methods that cannot be adequately performed in aircraft flights and drop-tower operations.

Areas in which such tests are needed include levitation techniques, containerless melting, dynamics of levitated liquids, directional solidification of metal and semiconductors, and performance characteristics of electrophoresis apparatus.

CHANGES FROM THE FY 1975 BUDGET ESTIMATE:

The reduction from the FY 1975 Budget Estimate in Ground-Based Investigations, Analyses and Studies resulted from the deferral of several planned projects into FY 1976.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In FY 1975 the Space Processing program concentrated on products and processes that appeared to have the potential for early applications. Preparations were made for tests of essential processes on longer duration rocket flights. These flights offer test durations of five to ten minutes and permit potential users to explore useful applications at relatively low cost. The program emphasis initiated in FY 1975 will continue during FY 1976 and the transition period. Projects to be undertaken will include: electrophoretic separation of cells and establishment of cell cultures; growth of electronic crystals in ribbon and sheet form; production of ultrahomogeneous semiconductor materials; vapor and solution growth of electronic crystals; refractory metal purification and grain refinement by vacuum/levitation processing; production of new types of optical glass from oxides; and controlled eutectic solidification for optical, electronic and specialty structural parts. Work in these areas will be oriented toward accomplishing critical tests on rocket flights where feasible, in order to acquire preliminary evaluations with minimum resource requirements. In addition to experimental work, economic analysis of the economics of future space processing operations will continue during FY 1976 and the transition period.

COMMUNICATIONS

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Cooperative applications satellite (CAS-C)	$2,760	$1,550	$1,550	$1,100	$100
Experiment coordination and operations support	800	3,700	6,200	2,900	800
Technical consultation and support studies	2,540	1,650	1,650	2,100	600

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Advanced communications research....	---	$1,400	$1,600	$1,400	$500
Multi-user communications experimental satellite (ATS-6)...	$16,200	---	----	---	---
Total.....	$22,300	$8,300	$11,000	$7,500	$2,000

The objective of this program is to keep the nation in the forefront of satellite communications technology through technological developments well in advance of commercially motivated initiatives. Current efforts include: the continued development of the Cooperative Applications Satellite-C (CAS-C); the operation of ATS-6, successfully launched in May 1974; the development of communications technology and concepts too advanced to warrant commercial development; the conduct of special radio interference and propagation studies; and provision of technical consultation services to other agencies as requested.

The successful launch of ATS-6 began a national and international experimental communications program in satellite broadcasting as compared to point-to-point capabilities of all other current systems. This new area of satellite communications was made possible by this most technologically advanced of the Applications Technology Satellite series. This spacecraft is now well into the most extensive and sociologically significant experiment program yet undertaken in the continuing investigation of the applications of space communications to benefit mankind. Continuing into FY 1976 and beyond, this spacecraft will play a major role in the definition of needs of communities for satellite supported health care delivery, delivery of educational services and other innovative applications of communications satellites.

After a one year period of operations, under an agreement between the U.S. and India, the spacecraft will be moved over a location to support the Indian Satellite Instructional Television Experiment (SITE). During the movement of the satellite to India, ATS-6 will provide television and data relay support to the Apollo Soyuz Test Project (ASTP). The activities of of ATS-6 are more fully discussed in the Experiment Coordination and Support narrative.

As the use of satellite communications proliferates both in the U.S. and abroad, the need for NASA to move into development and experimentation with the technology of future generations of communications satellite continues. This effort which is needed to maintain the United States'

position of leadership in this field, is sponsored by NASA in those areas of research which are not commercially motivated. This research also makes possible continued satisfaction of NASA's statutory responsibilities to provide technical consultation as Federal agencies and others request.

Cooperative Applications Satellite-C (CAS-C)

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Spacecraft testing.....	$280	$790	$470	$620	---
Experiments.....	2,405	560	980	330	---
Mission analysis and operation.....	75	200	100	150	$100
Total.....	$2,760	$1,550	$1,550	$1,100	$100
Delta (Launch vehicle procurement program).....	($1,000)	($3,600)	($3,800)	(---)	(---)

OBJECTIVES AND STATUS:

In April 1971, the Canadian Department of Communications (DoC) and NASA entered into an agreement to launch a Cooperative Applications Satellite (CAS-C, also referred to as the Communications Technology Satellite or CTS). The launch is currently scheduled for late 1975. The overall objective of this project is to develop technical capabilities for satellite communications with small ground stations in the newly allocated 12 GHz frequency band. Investigation of the use of frequencies above 10 GHz is a key part of the effort to find ways to relieve frequency crowding by proliferating communication satellite systems.

In this joint program, NASA is responsible for the 200-watt Transmitter Experiment Package (TEP), which is considered the prime technology experiment on CAS-C. NASA will also provide for the launch of the satellite on a Thor-Delta launch vehicle into geostationary orbit.

Canada is responsible for development and production of the spacecraft, and for its operation when it is at the desired geosynchronous station which will be about the longitude of San Diego. Use of the satellite time will be shared equally by the U.S. and Canada.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The changes in the FY 1975 Budget Estimate are the result of technical problems experienced in development of the Traveling Wave Tube (TWT). These problems caused delays in testing the TWT and the spacecraft.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Final development and production of TEP protoflight models is scheduled to be completed in FY 1975. Qualification and life tests will be conducted, and a flight unit will be delivered to the Canadian Communications Research Center for interaction with the Canadian-built protoflight spacecraft.

In FY 1976 acceptance testing and launch of the protoflight spacecraft is planned. Thermal vacuum and vibration testing will be conducted at Lewis Research Center (LeRC) followed by solar simulation, magnetic, and balance tests at Goddard Space Flight Center. Final network compatibility tests will be conducted before the protoflight spacecraft is shipped to the Eastern Test Range for launch operations. Launch is scheduled for the last quarter of 1975. Following insertion of the spacecraft into its final orbit, the performance of the TEP will be monitored by the LeRC ground terminal. This function as well as coordination of the United States user program will be continued through the remainder of FY 1976 and the transition period.

Experiment Coordination and Operations Support

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$800	$3,700	$6,200	$2,900	$800

OBJECTIVES AND STATUS:

The objectives of this program are to operate the communications satellites in orbit and conduct the experiments, as well as to coordinate the user experiments program after the NASA experimentation is completed. In 1969, NASA offered potential users of communications satellites the opportunity to use Applications Technology Satellites (ATS)-1, 3, and 5, for experimental purposes after the NASA experiments were completed. This offer received substantial response. Under the procedures established for such use, the experimenter provides funding for support of his experiment. NASA funds the continued operation of the satellites, provides experimenter time on the spacecraft and technical consultation to the experimenters as required. ATS-6, launched in May 1974, has followed the same pattern as ATS-1 through -5. The Cooperative Applications Satellite-C, (CAS-C) which has many approved experimenters, will also be operated under the same guidelines after launch in late CY 1975. NASA is cooperating with international, federal, regional and state agencies and industrial organizations in conducting these experiments covering a broad range of telecommunications objectives. A wide variety of technical experiments will also be conducted on these satellites to support the needs of NASA and other agencies.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

Changes from FY 1975 Budget Estimate are due to additional post-launch contractor support for ATS-6 and close-out of ATS-F backup spacecraft communications module.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In FY 1975 operations included ATS-1, 3, 5, and 6 and post-launch prime contractor effort and disposition of ATS related hardware was completed. Operations of ATS-6 will continue in FY 1976 and through the transition period. While the design life of ATS-6 is two years, the highly successful operations to date indicate this will probably be significantly longer. ATS-6 is currently performing 23 technological and applications-oriented experiments in the United States. In May 1975, the spacecraft will be moved from its position over the United States to a position over the Eastern Hemisphere where it will support an experiment program in cooperation with India and several European countries. It is planned to return the satellite to the U.S. late in FY 1976 and resume operations with U.S. experimenters.

Technical Consultation and Support Studies

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$2,540	$1,650	$1,650	$2,100	$600

OBJECTIVES AND STATUS:

The objective of this program is to provide technical consultation and support services on space telecommunications and spacecraft technology. NASA and other agencies benefit through orbit and frequency utilization studies which deal with the analysis, development and evaluation of frequency sharing and spacing criteria for satellites and propagation phenomena; and interference studies and experiments. Adverse effects of propagation phenomena and manmade noise on the design and performance of satellite systems will thus be determined. This program also includes systems reviews, evaluations and assessments for NASA and for domestic satellites and INTELSATS in support of the Federal Communications Commission.

Competition for orbit position and frequency spectrum is becoming extremely intense. By 1980 the increase in demand for orbit and spectrum assignments may grow too great to meet without a concentrated technical attack on the problems involved. The rapid growth in use of satellites

is expected to continue with new applications arising out of NASA's experimental programs and user experiments stimulating that growth. Similarly increasing worldwide interest in NASA's Earth Resources Technology Satellites (LANDSAT), Ocean Dynamics Satellites (SEASAT), and Synchronous Meteorological Satellites (SMS) will create demand for more advanced sensors and data collection services, all of which will require radio frequency spectrum and orbit space.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

To address the problems associated with meeting these needs this program proposes to continue to conduct in FY 1976 the studies, experiments and consultation services described in the first paragraph. NASA's unique resources, expertise and technology base are used to provide this support not only within NASA but also to fulfill NASA's statutory obligations to support the Federal Communications Commission and other organizations upon request. Support to non-NASA organizations is on a reimbursable basis where appropriate.

In FY 1976 it will be necessary to begin preparation for the 1977 World Administrative Radio Conference (WARC) on broadcast satellites and the 1979 WARC on space and terrestrial communications services. NASA has a particularly large interest in the 1979 WARC since the International Radio Regulations will be revised for the first time since 1959 and all space allocations, technical standards, and system parameters will be re-evaluated. As part of this preparation, frequency interference and orbit compatibility analyses required for NASA spacecraft, including Shuttle experiment packages, will be conducted. Analysis of NASA's future frequency allocation, bandwidth and orbit position needs will continue. Where possible, we will examine alternatives for sharing use of existing frequency allocations and identifying use of higher frequency bands to alleviate radio frequency and orbital space crowding problems. The NASA/Canadian Cooperative Applications Satellite (CAS-C), to be launched in late 1975, and NASA's ATS-6, will provide the major means available through the end of this decade for obtaining measurements required to develop design criteria for satellite systems using these higher frequency bands.

The results emanating from the Technical Consultation and Support Studies program will make a major contribution to the national effort in preparing for these WARCs, and will help provide the framework for orderly growth of existing satellite and terrestrial services and the inclusion of new services in the late 1970's and the decade of the 1980's.

Advanced Communications Research

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
---	$1,400	$1,600	$1,400	$500

OBJECTIVES AND STATUS:

The objective of this program is to develop the advanced technology and concepts for satellite communications needed to continue the United States as a leader in this field. The research planned is also necessary to maintain NASA's position as the Federal Government's center of expertise in nondefense spacecraft technology and space telecommunications. In addition, the research provides the advanced technology for NASA's own needs in space telecommunications as it brings into being the technological base from which future generations of communications satellites will emerge. Out of this, NASA is also able to continue meeting its statutory responsibility to provide technical consultation to users of communications satellite systems. In the future, the Space Shuttle is expected to be used to make demonstrations of new techniques in space telecommunications.

CHANGES FROM FY 1975 BUDGET ESTIMATE:

The increase in the FY 1975 Budget Estimate is to initiate an effort on a pilot project in the area of communications as a substitute for transportation.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Efforts initiated in FY 1975 in this program, to be continued in FY 1976 and the transition period, are in four major areas: improved and expanded utilization of the radio frequency spectrum; techniques for antenna beam shaping; development of improved modulation and data compression techniques; and more efficient transmitting and receiving devices.

In FY 1976 and the transition period, this effort will concentrate on developing methods for better utilization of microwave frequencies; and on performing research to open up new bands in the spectrum, such as the infrared and visible, for space research and applications. These efforts include the development of both components and spacecraft technology to produce more efficient and reliable communications.

To meet the anticipated needs for NASA, DoD, and commercial communications satellites to provide prescribed geographic coverage without intra- or inter-system interference, new techniques are being developed that will

51-423 O - 75 - 19

permit the design of antennas to produce beam contours conforming to such limits as the boundaries of a time zone or a state.

To increase the channel capacity of satellite systems within given size and weight limits for the satellite, and to reduce the per-channel cost of communications, research is underway on advanced transmitting device techniques and very low noise, uncoded receivers. To better utilize the presently assigned frequency bands, several improved modulation and data compression techniques and associated devices need to be investigated. Significant bandwidth conservation improvement should be obtained with the successful development of these techniques thereby increasing the amount of data a given bandwidth can contain and transmit.

DATA MANAGEMENT PROGRAM

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
---	$4,000	$4,000	$4,000	$1,500

OBJECTIVES AND STATUS:

The objective of this program is to improve the management of the data acquired through NASA's programs. As data from new sensors threatens to overwhelm existing data management facilities, two approaches show promise. One is to increase the capacity of the data handling system; the other is to reduce the amount of data collected to match the information requirements of the data users.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

The major FY 1975 activity in the Data Management program is concerned with getting a better definition of the information needs of users so that the design of data collection systems can be specified more precisely. This activity takes several forms. For example, regional surveys are being conducted to identify the end-use application of remotely-sensed data. One of these is being carried out by Washington University in St. Louis for the Missouri Basin. Another survey will be made by the City University of New York to clarify needs of state government management for similar data.

Experiments using data system simulators are being planned at NASA centers to devise better interactive techniques for defining users needs and developing data handling procedures to optimize the flow of data from the collection system to the user. This includes choosing data analysis and retrieval equipment, data interpretation techniques, and advanced processing methods.

Work is underway in defining systems characteristics for both generalized and discipline-oriented information management systems. The objective is to incorporate upgraded data management systems into NASA operations.

The second area of major emphasis in this program is Data and Information Technology. Work is going forward on integrating data formats for all sensing systems on a given space vehicle, while preserving the characteristics needed to process the collected data into useful information.

In addition to the systems and vehicle-oriented effort, hardware devices are designed, developed and tested. These include low cost data terminals, mini-computers and software for optimizing data handling. System hardware is being procured for the Atmospheric and Oceanographic Information Processing System, an advanced system for handling data from the SEASAT and meteorological data collection programs. The system can be used interactively to help data users define their needs for extracting specific data.

The FY 1976 and transition period effort in Data Management will build on the systems approach initiated in FY 1975. Definition of user needs will be expanded by conducting additional regional surveys and by having information users define their requirements more precisely by using simulation techniques. User-system information extraction experiments will assist in the formulation of better interactive techniques. Systems analyses will be performed to produce integrated sensor-to-ground-data-handling system models and analyze tradeoffs to improve procedures. Other activities undertaken will include extensive investigations of high data rate transmission and processing systems, including laboratory models to identify system characteristics and limitations.

SHUTTLE PAYLOADS

	1975			
	Budget	Current		Transition
1974	Estimate	Estimate	1976	Period
	(Thousands of Dollars)			
$4,500	$4,500	$4,500	$3,000	$1,500

OBJECTIVES AND STATUS:

The objectives of the Shuttle Payloads program for Space Applications are to develop the required instruments and the associated spacecraft technology that will advance the utilization of space for practical applications employing the planned manned shuttle sortie called Spacelab.

The Shuttle Spacelab is being developed to carry a variety of experiment payloads for the science and technology community. The Office of Applications plans to utilize the Shuttle Spacelab to complement its planned

automated spacecraft program in the 1980's by filling gaps in experiment data gathering areas, and by developing and demonstrating new space technology to the user community. It is anticipated that employing the Shuttle Spacelab as an R&D tool will reduce the cost of technology developments and thus provide the needed systems information at an earlier date than present day methods can.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In FY 1975, applications experiment concepts that appeared feasible for development in the 1980's were studied to ascertain their suitability for inclusion in Shuttle Spacelab missions. These definition studies have resulted in a selected list of experiments whose value to the various applications disciplines is high. Early Spacelab development testing of these experiments is desired to provide the technology for future applications.

During FY 1976 and the transition period, initiation of design and development is required on high priority experiments in order to have them available for Spacelab integration in 1979 and for flight in 1980-81.

The experiments tentatively selected for design and development efforts in FY 1976 are, for Communications: a radio frequency interference (RFI) mapping survey to characterize the sources of ground-based radio transmissions that interfere with space operations, and the development of an advanced kilowatt-power, communications tube for application to broadcast communications satellites; for Earth Observations: zero-gravity cloud physics laboratory to conduct atmospheric research that will provide data to assist in the understanding of the processes responsible for the formation of clouds, resulting cloud dynamics and the release of precipitation, and a high speed interferometer instrument that has the capability to sense and measure trace constituent gases in the atmosphere for pollution monitoring applications; and for Space manufacturing: payloads that will develop the techniques for the preparation of biological and electronic materials including organic, glass, ceramic, metallurgical, and chemical processes.

ADVANCED APPLICATIONS FLIGHT EXPERIMENTS

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)				
Design and development of advanced experimental instruments	$4,700	$4,700	$4,700	$4,700	$1,300

OBJECTIVES AND STATUS:

The objective of the Advanced Applications Flight Experiments (AAFE) program is to develop application experiments from which future missions and flight experiments for approved flights can be proposed. In pursuing this objective, the AAFE program places emphasis on the early solution of technical problems and on engineering development of instrumentation without commitment to a definite flight mission. In this way, the AAFE program activities reduce the technical, funding and schedule risks of the flight programs by off-line development of experiments prior to flight commitments.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In FY 1975, the AAFE program conducted a number of aircraft and balloon flight tests and evaluations to verify performance and applications potentials of experiments developed earlier. For example, a Radiometer/Scatterometer was flown in a C-130 aircraft over the East Coast to evaluate its performance for measuring oceanographic parameters. Several helicopter flight tests of a Fraunhofer Line Discriminator were made to measure stressed trees, water currents, land pollution and oil spills in water. The Correlation Interferometer was flown in helicopter tests to evaluate its capabilities to measure atmospheric pollution.

During FY 1976 and the transition period, portions of the AAFE funding will be used to continue experiments initiated in each of the applications discipline areas. This will include an Active/Passive Multispectral Scanner to measure atmospheric path characteristics, water depth, turbidity, and vegetation canopy height. A High Resolution Laser Radar will be developed to measure vertical profiles of aerosol distribution, humidity, and alkali metal vapor.

In the areas of bathymetry, algae detection and mapping and oil slick detection, a High Pulse Repetition Rate Lidar will be developed. In addition to continuing these ongoing tasks, new experiments will be solicited for FY 1976. We expect to initiate development of active instrumentation such as lasers and radars to take advantage of advances in this technology and its inherent applications potential. These instruments will become primary tools for future applications missions since they have the capability of providing their own illumination at the target which significantly enhances remote detection and measurements.

APPLICATIONS SYSTEMS ANALYSES

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Applications studies	$1,265	$5,000	$5,000	$5,000	$1,400

OBJECTIVES AND STATUS:

The major objectives of the Applications Systems Analyses program are to determine the probable benefits of proposed and ongoing applications as well as to understand the needs of users of applications systems, and to identify and investigate the potential uses of space-derived technology.

An important effort in the Applications Systems Analyses program is the assessment of when and how applications technology should be made available in operational status for transfer to operating agencies or the private sector. Establishing criteria for determining when this transition is technically, economically and institutionally appropriate is being developed.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In FY 1975, cost benefit studies were conducted in agricultural forecasting and land use planning. In addition, the SEASAT cost benefit study provided insight into the potential value of this system to the user community. Preliminary economic assessments are being made on potential commercial space processing systems. Activities continued on the Activated Carbon Wastewater Treatment System (ACTS) which has led to a grant from the EPA to Orange County, California, to develop a 1,000,000 gallon-per-day municipal pilot plant.

In FY 1976, some of these activities will be continued and a number of new studies and activities will be initiated which will be continued in the transition period. Future cost benefit studies will be conducted to better understand the potential economic benefits of new Applications programs.

In addition, major new activities will be undertaken to more directly meet with and educate the new user communities in all of these areas.

APPLICATIONS EXPLORER MISSIONS (AEM)

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
AEM-A (Heat Capacity Mapping Mission).....	---	$2,600	$2,600	$3,500	$600
AEM-B (Stratospheric Aerosols and Gas Experiment).....	---	---	---	2,400	2,000
Total.....	---	$2,600	$2,600	$5,900	$2,600
Scout (Launch vehicle procurement program).	(---)	(---)	(---)	($2,000)	(---)

RD 7-55

OBJECTIVES AND STATUS:

The objective of the Applications Explorer Mission program is the development and launch of low cost, Scout-launched missions to support research in earth resources surveys, environmental quality, weather and climate, ocean studies, and space communications. Each mission will be tailored to the specific area of research and to the orbital requirements.

The first mission, the Heat Capacity Mapping Mission, is based on the adaptation of a spare Nimbus-5 flight instrument to be flown in a unique orbit for the collection of predawn and early afternoon time data required for the determination of thermal inertia of surface materials. Studies of the thermal inertia, an identifiable characteristics of various materials, will be used to develop maps of rock types for applications to mineral potential assessments. Data acquired with this mission in a secondary sense will also be useful for studies of soil moisture, for the mapping of thermal effluents, for the measurement of plant canopy temperature, and for the mapping of snow coverage. This mission is to be launched in late 1977 into a sun-synchronous polar orbit which will allow complete day/night coverage of the United States every eight days.

The second mission, the Stratospheric Aerosol and Gas Experiment, will use a photometer to develop monitoring techniques for the detection and mapping of stratospheric aerosols and ozone concentrations and distributions. The measurement technique is based on observations of atmospheric attenuation of solar radiation near the earth's limb (horizon) in four bands during satellite sunrise and sunset.

Stratospheric aerosols and ozone concentrations can be altered by natural and man-induced changes. The measurement of concentrations is required in order to assess the role which these constituents play in the radiation balance of our environment on a global scale. The earth's radiation balance is an important factor in the determination of climatic changes. In addition, knowledge of the variations in the ozone blanket is important because of the protection from extreme ultraviolet radiation which this blanket affords the earth. This mission will be launched in 1979 into a 50^{o} inclined orbit and will provide bi-weekly coverage of aerosols and ozone for latitudes from 72^{o} north to 72^{o} south. A similar instrument to be flown on Nimbus-G in 1978 will provide complementary measurements of aerosols at polar latitudes. The data from these two missions will provide the first global scale measurements of particulates which are important to the studies of the stratosphere.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

In FY 1975, design and development of a spacecraft base module to be used for these missions and for modification of the instrument for the Heat Capacity Mapping Mission were initiated.

During FY 1976 and the transition period, design of the base module will be completed and fabrication of a base module for the AEM-A will be essentially complete. Modification of the Sensor will be initiated and the refurbishment and reassembly will be undertaken. Base module procurement for the AEM-B and fabricate of flight hardware will be initiated. Design of the instrument for the Stratospheric Aerosol and Gas Experiment will be nearly completed.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1976 ESTIMATES

RESEARCH AND DEVELOPMENT PLAN FOR

AERONAUTICS AND SPACE TECHNOLOGY PROGRAMS

Programs	Budget Plan				
		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)				
Aeronautical research and technology.....	$168,000	$166,400	$166,400	$175,350	$46,800
Space and nuclear research and technology.....	66,307	72,365	71,365	74,900	22,300
Total.....	$234,307	$238,765	$237,765	$250,250	$69,100

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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Research and technology base	$79,993	$83,900	$83,900	$85,100	$23,800
Systems studies	3,100	3,000	3,000	3,000	700
Systems technology programs	26,351	31,700	31,700	46,550	15,800
Experimental programs	58,556	47,800	47,800	40,700	6,500
Total	$168,000	$166,400	$166,400	$175,350	$46,800
Distribution of Program Amount by Installation					
Johnson Space Center	$259	$164	$100	$280	$70
Marshall Space Flight Center	647	647	650	600	150
Jet Propulsion Laboratory	702	620	878	1,200	390
Wallops Flight Center	137	124	285	250	110
Ames Research Center	46,155	44,153	46,673	44,150	12,000
Flight Research Center	12,164	12,898	12,587	17,400	4,300
Langley Research Center	47,688	60,428	60,985	64,740	17,000
Lewis Research Center	57,925	45,736	41,754	43,990	12,000
Headquarters	2,323	1,630	2,488	2,740	780
Total	$168,000	$166,400	$166,400	$175,350	$46,800

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 AND TRANSITION PERIOD ESTIMATES

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION

The objectives of the Aeronautics program for FY 1976 and the transition period are to advance aeronautical technology to make possible safer, more economical and environmentally acceptable air transportation systems which are responsive to current and future national needs; to maintain the strong competitive position of the United States in the international aviation market place; and to support the military in maintaining the superiority of the nation's military aircraft.

CHANGES FROM FY 1975 BUDGET ESTIMATE

There were no changes from the FY 1975 budget estimate for the Aeronautical Research and Technology program as a whole. However, funding shifts did occur between individual programs within the Aeronautics program. Some of these apparent funding changes are due to a restructuring of the Aeronautics program and simply reflect new program locations within the overall program structure rather than changes in program emphasis. These changes will be addressed under the individual programs involved. Funding changes that occurred that were significant in terms of a change in program emphasis will also be specifically addressed under the individual programs involved.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

A strong research effort will be maintained in the disciplinary areas of materials, structures, avionics, propulsion, aerodynamics and man-vehicle interactions to provide advanced technology to meet the future needs of civil aviation. The Aeronautics program includes a major effort aimed at reducing aircraft energy consumption and the undesirable environmental effects of noise and pollution. This effort is directed at providing the technology for quiet, clean and efficient propulsion systems; the reduction of aerodynamic drag; the application of active control concepts, and advanced materials and structural concepts to aircraft to reduce weight and improve operating efficiencies; and a characterization of nonpetroleum based fuels for aircraft. Another major area of program emphasis is concerned with improving aircraft terminal area operations and safety through the development of technology in areas such as avionics systems, operating procedures, crashworthy aircraft structures, and fire resistant aircraft interior materials. These technology efforts are integrated with additional focused technology efforts to provide the technology for advanced long haul and short haul air transportation system concepts for the future. The short haul program focuses

on Short Takeoff and Landing (STOL), Vertical Takeoff and Landing (VTOL) and rotorcraft systems; while the long haul program focuses on Conventional Takeoff and Landing (CTOL) subsonic systems with a modest effort aimed at developing supersonic and hypersonic technology to provide options for aircraft of the future.

The Aeronautics program also supports the military by providing an advanced technology base which may be uniquely applicable to military aircraft or applicable as well to civil aircraft, and by providing technical problem solving support for current military aircraft development.

The structure of the Aeronautics program has been modified to reflect the logical flow of the research and technology effort. The activities carried out in the Research and Technology Base are oriented toward establishing a solid foundation embracing all of the relevant disciplines and a wellspring of ideas for advanced concepts; the System Studies activity provides a basis for decisions regarding emphasis and priorities in the Research and Technology Base program and identifies and evaluates potential applications of advanced concepts; the Systems Technology Programs are technology demonstration/proof-of-concept activities for concepts which have matured under the Research and Technology Base and are ready for systems integration and demonstration, or the project definition phase of potential future Experimental Programs; and the Experimental Programs involve multidisciplinary concept demonstration and major research vehicle development.

The Aeronautics program for FY 1976 and the transition period contains several planned program augmentations in the Systems Technology programs area. The design, construction, and testing of propulsion system subassemblies and components for an advanced energy conservative turbofan, and the integration and evaluation of fuel conservative aircraft technologies are directed at energy conservation and improving aircraft operating economy. The development of long lead time technology related to flight weight cryogenic tanks and insulation required to utilize hydrogen as an aircraft fuel represents a significant step forward in the search for an abundant alternative to hydrocarbon fuels. Common components for variable cycle engines which show great promise for efficient operation over a wide range of subsonic and subsonic/supersonic flight conditions will be designed, developed and tested. Propulsion, structures and aerodynamics technology will be developed for future hypersonic applications. An effort to develop solutions to offset the increase in "human error" caused commercial aircraft accidents, and the identification of new fire resistant, low toxicity materials for use in aircraft will make significant contributions to improving air transportation safety. NASA technology will be applied to reduce the undesirable environmental effects of noise and pollution from general aviation turbofan engines. An effort will also be initiated to improve capability for understanding and avoiding aeroelastic instability in turbine engine fan blades.

BASIS OF FUND REQUIREMENTS

Research and Technology Base

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Materials research and technology	$6,687	$6,900	$6,700	$6,200	$1,700
Structures research and technology	6,204	7,000	6,900	6,250	1,800
Propulsion environmental impact minimization research and technology	13,097	10,400	10,400	11,410	3,200
Propulsion components research and technology	8,529	9,000	8,900	9,050	2,700
Air breathing engine systems research and technology	7,796	8,000	8,000	8,150	2,000
Fluid and flight dynamics research and technology	8,667	9,400	9,400	10,200	2,900
Avionics research and technology	3,302	3,800	3,700	3,580	1,000
Aircraft operations and safety research and technology	3,638	3,900	3,900	3,900	1,100
Low speed vehicle aerodynamics and flight dynamics research and technology	10,466	11,600	12,300	12,500	3,500
High speed vehicle aerodynamics and flight dynamics research and technology	7,932	9,100	8,900	8,830	2,500
Aeronautical man-vehicle research and technology	3,675	4,800	4,800	5,030	1,400
Total	$79,993	$83,900	$83,900	$85,100	$23,800

CHANGES FROM FY 1975 BUDGET ESTIMATE

Changes from the FY 1975 budget estimate for the Research and Technology Base as a whole were negligible. However, funding shifts did occur between the disciplinary programs within the Research and Technology Base, in order to increase the program emphasis in the Low Speed Vehicle Aerodynamics and Flight Dynamics program on upper-surface-blowing propulsive-lift concepts. Funding changes that occurred that were significant in terms of a change in program emphasis will be specifically addressed under the individual programs involved.

Materials Research and Technology

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(In Thousands of Dollars)		
6,687	6,900	6,700	6,200	1,700

OBJECTIVES AND STATUS

This program involves the study of advanced materials with the objectives of improving the safety, performance, and economy of civil and military aircraft. Emphasis is on high temperature turbine engine materials and low weight, high strength airframe materials which are also fire resistant.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The funding change reflects that the costs of services in support of the in-house materials research efforts were less than anticipated.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

During FY 1976 and the transition period, basic materials research will continue to be focused on understanding strengthening and failure mechanisms in alloys, composites, and ceramics, and the phenomena of oxidation and corrosion.

The effort on high temperature materials in FY 1976 and the transition period will emphasize oxide-dispersion strengthened nickel base alloys, and directionally solidified eutectics for use at 2,000 degrees Farenheit and 1,900 degrees Farenheit, respectively. The best method to improve the toughness of ceramics will also be determined.

The approach to obtaining safer, lightweight materials in FY 1976 and the transition period will emphasize the synthesis of new and improved polymers and composites, and more efficient joining techniques. Fire resistant, non-toxic polymers will be evaluated for use in aircraft interiors, and for improved composite matrices. Advanced polymeric systems will also be synthesized for better adhesives to insure safer structures.

Underlying this program will be a study of the fatigue and fracture behavior of both metal and composite materials. This study should lead to the development in FY 1976 of improved life prediction procedures and fracture control techniques for greater reliability and lower cost of both aircraft structures and propulsion systems.

Structures Research and Technology

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(In Thousands of Dollars)		
$6,204	$7,000	$6,900	$6,250	$1,800

OBJECTIVES AND STATUS

This program provides technology to improve the safety, durability, and economy of commercial, military, and general aviation aircraft by advancing the state-of-the-art in airframe structures. The specific activities undertaken are selected to provide the maximum benefits in critical areas and are coordinated with related efforts in other agencies to avoid unnecessary duplication.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The funding change reflects that the costs of services in support of the in-house structures research efforts were less than anticipated.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

In FY 1976 and the transition period, studies of advanced concepts will be continued to explore structural arrangements which will improve efficiency and safety of current types of aircraft and provide feasible concepts for advanced aircraft. One important facet is a joint NASA/Federal Aviation Agency (FAA) program to improve the crashworthiness of general aviation aircraft. Development of analytical methods for predicting structural behavior in crash impacts will continue together with crash tests of flood damaged small aircraft to provide data needed to confirm the accuracy of analytical predictions. Experimental evaluations of high temperature structural concepts for hypersonic aircraft are being conducted. These will include high temperature wind tunnel and radiant heating tests of actively cooled structures as well as hot structures.

Improved methods for predicting design loads, aeroelastic behavior, and dynamic response for aircraft structures will continue to be developed during FY 1976 and the transition period. Research will include experimental and analytical studies of the complex factors affecting panel flutter, unsteady pressures in cavities open to the airflow, and improved computer methods for predicting aeroelastic loads including those due to gusts and active controls. Emphasis will also be given to development of unsteady aerodynamic theory in the difficult transonic regime supported by wind tunnel tests and a drone flight program. Applications of active control technology will be pursued to permit minimization of aeroelastic response; these will also be verified by wind tunnel and drone flight tests.

Systematic experimental and analytical studies will be conducted in FY 1976 and the transition period to improve design procedures needed to assure structural integrity in highly efficient aircraft structures. A life prediction rule for structural components subjected to complex stress histories will be based on consideration of the continuously changing residual stresses caused by local plasticity. A design rule for predicting rates of fatigue crack propagation under complex stress histories will be based on the NASA-developed crack closure concept. Analyses of fatigue crack propagation in stringer-stiffened panels will be extended to predict residual strength of wing structures with multiple failure nuclei. The fatigue behavior of composite materials with and without outdoor environments will be studied to provide background for developing life prediction rules and damage-tolerant composite structures.

In FY 1976 and the transition period research will be continued to improve the understanding and prediction of the structural behavior of filamentary composites. Improved theories being developed will be investigated in laboratory tests of composite components. Demonstration of composite secondary structures in routine airline service will continue; components include L-1011 fairings, B-737 spoilers, and DC-10 rudders involving 48 aircraft. The components on these aircraft will each have accumulated an average of 2,940 flight hours by the end of FY 1976; the flight service evaluations will continue in subsequent years to provide confidence for industry and airlines in the long term performance of composite structures.

Technology will be developed for advanced structural analysis and design methods during FY 1976 and the transition period. Effort will focus on more efficient and reliable techniques for complex problems and the potential for incorporating new and unique methods in large computer programs such as NASA Structural Analyses Program (NASTRAN) and Integrated Program for Aerospace Vehicle Design (IPAD).

Propulsion Environmental Impact Minimization Research and Technology

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(In Thousands of Dollars)		
$13,097	$10,400	$10,400	$11,410	$3,200

OBJECTIVES AND STATUS

The propulsion environmental impact minimization research and technology program will provide through basic research, applied technology, and experimental engineering the knowledge and understanding necessary to reduce propulsion system noise and exhaust pollutant emissions to help meet national environmental objectives. In addition, the program will provide improved methods for predicting noise and pollution impact on the environment, and for assessing the interaction of aircraft emissions in the atmosphere.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

In the area of propulsion noise reduction, research will be continued in FY 1976 and the transition period on fundamental studies of generation, propagation, and suppression of aircraft noise. The studies include extensive analytical and experimental research related to inlet and fan duct acoustics, turbomachinery noise (fan, compressor, combustor, turbine, nozzle, etc.) jet/flap impingement noise, wing shielding and forward velocity effects on noise, atmospheric propagation and attenuation, and inflight field measurements of noise.

In the area of noise prediction, research efforts are underway through the NASA Aircraft Noise Prediction Program Office, to improve techniques for accurate prediction of ground noise levels of operating and future aircraft to establish total acoustic characteristics, identify key sensitivity parameters and guide future research efforts. Interim noise prediction programs became operational in mid-1974, and in December 1974 the publication of key technology documents began. These documents present the state-of-the-art in noise source predictions, noise reduction technology, atmospheric propagation phenomena and other effects necessary for reliable prediction of the ground noise environment produced by aircraft. Based on these documents, the design and development of a new and much more accurate aircraft noise prediction program will continue during FY 1976 and the transition period. The objective of this work is to improve the accuracy of predicted noise contours (footprints) to within $\pm$ 1.5 decibels.

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During FY 1976 and the transition period, in the area of pollution reduction a major NASA activity will be to develop and demonstrate low exhaust emission technology for all thrust classes of aircraft gas turbine engines and aircraft piston engines. Advanced exhaust emission reduction research includes investigations related to injection of hydrogen into aircraft piston engines and aircraft gas turbine combustors to achieve very low nitric oxide emission levels.

Research activities during FY 1976 and the transition period will strive to determine the effects of exhaust emissions interacting with the atmosphere. A major element of this research is the Global Air Sampling Program (GASP) which will measure aircraft exhause emission concentrations, over a five year period, along the world airways. Up to five specially instrumented Boeing 747 aircraft in commercial service will be used in the program. The first instrumented flight was in a United Airlines B-747 in December 1974. The second instrumented aircraft will be a Pan American B-747, to be flown in February 1975. Negotiations are underway with three other international airlines to obtain the desired global coverage for the GASP program. NASA is also developing a small, low cost, simple, remotely piloted vehicle (Mini-Sniffer) for in situ measurement of turbulence, atmospheric trace gases and particulate constituents at altitudes up to 100,000 feet. Air sampling measurements will be made with the Mini-Sniffer during FY 1976 and the transition period.

Other research during FY 1976 and the transition period will include fundamental studies of chemical reactions, kinetic rates and fluid mechanics models necessary to understand the processes involved in the injection of emission products into a supersonic aircraft wake and their subsequent dispersion into the stratosphere. Reactions of interest are those associated with nitric oxide/nitrogen dioxide conversion, hydroperoxyl and hydroxyl radical, and nitrogen "sinks" in the stratosphere such as nitric acid, particularly as they influence natural ozone concentrations. Reaction studies are conducted with consideration of exhaust particulates and the effects of low concentrations of ozone, various hydrocarbons and water vapor chemistry in the presence of solar ultraviolet radiation.

Propulsion Components Research and Technology

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$8,529	$9,000	$8,900	$9,050	$2,700

OBJECTIVES AND STATUS

The aeronautical propulsion components research and technology program objectives are to increase efficiency, increase operating range, improve specific fuel consumption and reduce the weight of the many interactive components making up aircraft engines and propulsion system installations.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The funding change reflects the deferral of the design, fabrication and testing of a final stage of a compressor. This research and technology effort supports the Advanced Multi-State Axial Flow Compressor program which was delayed in starting during FY 1975.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Inlet and nozzle research during FY 1976 and the transition period will concentrate mainly on development of highly sophisticated analytical techniques for accurately predicting complex external and internal flow fields associated with supersonic inlets and nozzles. A considerable portion of the research is concerned with the effect of aircraft maneuvers on inlet behavior since inlet performance during maneuvers can be seriously degraded because of air flow distortion. Airframe interference effects on exhaust nozzle performance is also being examined. During FY 1976 and the transition period, a methodology for prediction of inlet/engine compatibility will be developed, including effects of inlet flow distortion on engine operational stability.

The fan, compressor and turbine technology effort during FY 1976 and the transition period will stress achievement of high performance with minimum degradation of component efficiency. This is implemented by high tip-speed fan research, highly loaded compressor and turbine stage research, and high temperature turbine cooling and aerodynamics interactions. The effects of casing treatment on stable operation of high performance compressors under adverse conditions will be evaluated. Also FY 1976 and the transition period will see significant progress in analytical methodology for calculating compressor flow fields. Turbine research will continue in concentrating on the problems of aerodynamic design of high power, low speed turbines, and cooling techniques applicable to ultrahigh temperature (3,000-3,500 degrees Farenheit) turbines. The high power, low speed turbine research is expected to result in demonstrating performance of an advanced fan drive turbine with significantly fewer stages than contemporary turbines, for the same power output.

A program of research on combustion and augmentation systems technology, quite independent of exhaust emission pollution reduction, will look into techniques for achieving the high exit temperatures and efficiencies required by advanced engines. In FY 1976, in one of the key programs in this area, near 100 percent efficient operation at 3,500 to 4,000 degrees Farenheit will

be demonstrated using an advanced version of an aircraft type swirl can modular combustor originally designed for 2,400 degrees Farenheit temperatures.

Drive system mechanical components provide the backbone, literally supporting the major thrust producing devices, and includes bearings, shafts, seals and lubrication systems. On-going programs from prior years are continuing, spurred on by the importance of such components as improved engine seals to reduce fuel consumption. In particular, compliant lift-pad compressor end-seal operation will be demonstrated in the laboratory in FY 1976. A seal of this type can effect a reduction of up to two percent in a commercial jet engine's fuel consumption.

Liquid hydrocarbon fuels technology research is focused on characterization of alternative hydrocarbon fuels derived from our abundant supplies of indigenous raw materials--coal and shale oil, including the effects of promising candidate fuels on propulsion systems and components, as well as on exhaust emissions. In FY 1976 and the transition period, the more significant properties of jet fuel derived from shale and coal will be identified.

Air Breathing Engine Systems
Research and Technology

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$7,796	$8,000	$8,000	$8,150	$2,000

OBJECTIVES AND STATUS

The air breathing engine systems research is directed toward the attainment of technology for reducing both the costs and time required for new engine development programs through improved engine systems design and analysis techniques, and to investigate potential new system concepts.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

In the area of propulsion system dynamic behavior and control, the effects of transient flow conditions on gas turbine engine systems and components, and new on-line digital computerized control system theories will be demonstrated on complete propulsion systems during FY 1976 and the transition period. Flight tests of an advanced digital control system developed under a joint Air Force/NASA program will be conducted to demonstrate the potential of a system capable of sensing, computing, and controlling a optimum operating conditions the inlet, engine, and exhaust nozzle system of an F-111 airplane.

In FY 1976 and the transition period the intergration of components into complete turbine engine systems will be investigated to define basic performance limits, and evaluate the overall responses to dynamic disturbances and distortions. A joint NASA/United States Air Force full scale engine research program will emphasize acquisition of basic data and phenomenological understanding leading to better analytical and design procedures having the highest potential for reducing engine development cost and time, and which reduce dependence on trial and error development empiricism. Research will be undertaken to determine precisely the causes and relationships between component mechanical or physical condition and performance loss in engines. Several airline engines with varying degrees of wear and deterioration will be tested to determine quantitatively the effect of work components on engine performance.

Low cost engine systems research will be continued in FY 1976 and the transition period with exploration of promising design characteristics and fabrication techniques of interest for general aviation applications. A lightweight multiroller speed reducer for turbofan engines will also be studied.

During FY 1976 and the transition period in the area of hypersonic propulsion, a preliminary structures and systems study of a scramjet module design will be completed, and aerothermal tests of a subscale model will be conducted at Mach numbers of 4 and 7. An evaluation of methods for achieving adequate thrust at low speeds will be completed.

Advanced systems studies conducted during FY 1976 and the transition period will place increased emphasis on technology needed for achieving reductions in fuel consumption. Near term applications will include studies of the substitution of improved parts in existing airline engines. A study of next generation engines based on current design practice may achieve a 15 percent reduction in fuel consumption below that of current engines, by stressing energy conservation in the design of the engine components. Other studies will concentrate on the fuel savings achievable through use of relatively unconventional but very energy conservative devices such as the regenerator. Incorporation of the energy conservative components and devices into an engine could reduce fuel consumption by about 30 percent below that of current engines.

Fluid and Flight Dynamics Research and Technology

	1975			
	Budget	Current		Transition
1974	Estimate	Estimate	1976	Period
	(In Thousands of Dollars)			
$8,667	$9,400	$9,400	$10,200	$2,900

OBJECTIVES AND STATUS

The thrust of the fluid and flight dynamics program is to advance our understanding and predictive capability of aerodynamic pheonomena to permit increased proformance optimization for more efficient, fuel-conserving advanced aircraft, and to ensure reduced environmental effects and improved safety of advanced aircraft in early design stages.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

In the area of prediction of aerodynamic phenomena, theoretical prediction techniques are being developed to predict complete aerodynamic characteristics of complex three-dimensional aircraft configurations, so that preliminary design concepts can be evaluated with marked reduction in costly, energy-consuming wind tunnel tests.

During FY 1976 and the transition period, the present predictive capability will be extended to configurations of increased complexity, with particular emphasis on the development and use of advanced turbulence modeling techniques to account for viscous effects on flow phenomena.

Efforts on reducing adverse environmental and aerodynamic effects are concentrated on such problems as wake vortex turbulence, airframe generated noise and airframe buffet. Research will continue in 1976 and the transition period to refine a number of aerodynamic alleviation devices for eliminating the wake vortex hazard restriction on aircraft landing operations, and to evaluate the operational feasibility tests of the most promising methods. Airframe noise activities will concentrate on developing and evaluating means for reducing the noise of flaps, landing gear, cavities and protuberances so that planned reductions in overall aircraft noise can be accomplished on schedule.

A focused effort is underway to provide improved single and multi-element high-lift airfoils for advanced general aviation, transport and rotating-wing aircraft. In FY 1976 and the transition period research will continue to generate airfoil design methodology, advanced airfoils for both subcritical and supercritical aerodynamic regimes and provide high quality data on selected configurations, particularly at high Reynolds number and angles of attack. Specifically, improvements will be sought in subsonic drag prediction and the ability to incorporate boundary layer and flow separation-reattachment effects in mixed subsonic-transonic flows in the predictive and design process. Three-dimensional viscous-potential flow interaction over highly swept wings with leading and trailing edge high lift devices will continue to be studied.

Another aspect of the program is concerned with developing improved experimental techniques, analytical methods and test facilities to increase the reliability of wind tunnel evaluations of advanced aircraft concepts.

Emphasis in FY 1976 and the transition period will continue on providing advanced transonic tunnel walls and support systems to minimize interference effects (including the use of magnetic suspension), on defining and minimizing stream turbulence factors at transonic and supersonic speeds, and on determining transonic three-dimensional scale effects on highly swept wings.

Significant emphasis is being placed on continuing efforts to provide a basic understanding of the aerodynamic characteristics of aircraft at high angles of attack, particularly on investigating the fundamental nature of stall/spin, the use of control systems to prevent divergence at high angles of attack, and the aerodynamic characteristics responsible for spin behavior. Efforts toward the definition of handling qualities criteria for highly augmented vehicles will also continue through FY 1976 and the transition period.

Avionics Research and Technology

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$3,302	$3,800	$3,700	$3,580	$1,000

OBJECTIVES AND STATUS

The avionics research and technology program is focused on the design, development and test of improved aircraft guidance, navigation, control, display and communication subsystems for general aviation, sort haul, vertical takeoff and landing, and long haul transport aircraft.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The funding change reflects the deferral of work on an advanced receiver for civil aviation use which is insensitive to multipath effects. Deferral of the effort was considered to be acceptable due to the lack of the near term requirement for the receiver.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Flight tests of a time optimized, four-dimensional (4-D) guidance system have been successfully completed. Flight testing of an advanced fuel optimized 4-D system for Short Takeoff and Landing (STOL) aircraft will be completed during FY 1976. Subsequent analysis and simulation efforts will derive a full-flight-envelope autopilot design for powered-lift STOL aircraft by FY 1977. A practical assessment, both analytical and experimental, of Regional Navigation (RNAV) schemes for general aviation aircraft will be completed by the end of FY 1976.

During FY 1976 and the transition period promising new concepts offering the potential of significant improvements in performance and/or cost of avionics systems will be investigated. A split-surface stability augmentation system, which can reduce pilot workload and provide better aircraft handling and ride characteristics, will be flight tested in a Beech 99 commuter airline type aircraft. A low profile microstrip antenna, with a production cost of less than 1/8 of present antennae has been developed. A computer program to determine its characteristics in aircraft configurations will be developed in FY 1976, and the antennae will be flight tested on model airplanes in FY 1977.

Highly reliable, fault tolerant computers are being studied for the flight control of civil aircraft. The design of different fault tolerant computer organization concepts will be completed during FY 1976 and the transition period.

Automated Vertical Takeoff and Landing (VTOL) avionics efforts are aimed at the synthesis of integrated avionics systems for reliable and cost-effective automated flight, with primary emphasis on future helicopters and VTOL aircraft. Navigation and guidance requirements for commercial VTOL operations have been defined. Flight testing of an acoustic altimeter breadboard and a laser gyro strapdown navigation system will be completed in FY 1975. Flight testing of automatic and manual displays will be initiated in early FY 1976 and completed in FY 1977. The complete integrated guidance system is scheduled for flight tests on a CH-47 research helicopter by FY 1980.

Aircraft Operations and Safety
Research and Technology

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$3,638	$3,900	$3,900	$3,900	$1,100

OBJECTIVES AND STATUS

Aircraft operations and safety research and technology programs provide a research and technology base which can be used to solve a wide variety of aeronautical safety and safety-related operational problems. Three program elements provide a focus for individual research efforts: (1) expansion of basic knowledge of atmospheric processes; (2) aircraft safety technology; and (3) aircraft system operational efficiency improvement.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

In the area of expanding our knowledge of basic atmospheric processes, improvement of our understanding of natural atmospheric behavior as it affects

the safe and efficient operation of aircraft is a continuing, long term process. FY 1976 and the transition period research will continue the process of functionally defining and describing atmospheric phenomena in a way that will facilitate a utilitarian use of this information by designers, operators, and forecasters. Research will also continue in the areas of fog formation and dissipation, and high altitude thermal and pressure gradients.

In the area of aircraft safety technology, research is focused on developing a technology base which can be used to reduce accident opportunities and to minimize accident fatalities and damage. This effort includes in-flight and post-crash aircraft fire prevention and protection, and lightning strike hazards reduction. In FY 1976 and the transition period, effort will continue on the test and evaluation of aircraft interior materials. A laser-Doppler system will be employed in vortex flight research programs and in flight detection of clear air turbulence. Work will continue in refining the structural failure model for high speed rotors and applying results to the concept development of burst-resistent rotors.

In the area of improving the operational efficiency of aircraft systems, the focus is to selectively boost technology development which will permit increases in the service life and efficiencies of aircraft subsystems. During FY 1976 and the transition period, new tire tread stock recapped on B-727 tire carcasses will be subjected to in-service evaluation. Also, Short Takeoff and Landing (STOL) aircraft will be fitted with a research landing gear to permit evaluation of operation in extremely high crosswinds. Flight test instrumentation needs for advanced in-house flight testing will be evaluated for possible new concept development activity.

Low-Speed Vehicle Aerodynamics
and Flight Dynamics Research and Technology

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$10,466	$11,600	$12,300	$12,500	$3,500

OBJECTIVES AND STATUS

The objective of this program is to develop and demonstrate the advanced technology required for improvements in the integrated aerodynamic performance, noise, stability, control, handling qualities and flight dynamics of four low-speed aircraft categories, i.e., general aviation, advanced rotorcraft, advanced vertical take-off and landing and powered-lift.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The funding for this program was increased to enhance the technology effort on upper-surface-blowing (USB) propulsive-lift concepts in response to the usage of USB on ongoing projects such as the Air Force Advanced Medium Short Take Off and Landing Transport (AMST) and the NASA Quiet Short Haul Research Aircraft (QSRA).

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

During FY 1976 and the transition period, the effort in general aviation will continue to be concentrated on the generation of reliable design data for spin resistant aircraft. A flight test program will verify the results of spin tunnel and radio controlled model tests and the effectiveness of a rocket spin recovery system. Aerodynamic performance studies will concentrate on the flight test verification of improved low speed airfoil sections and development of techniques for reducing drag penalties associated with engine cooling. Flight and handling qualities efforts will emphasize techniques for more precise flight path control during approach and landing.

In the advanced rotorcraft program, in FY 1976 and the transition period, a new rotor test apparatus and laser Doppler velocimeter will be used in the 40-by 80-foot wind tunnel to investigate various rotor systems for reduced noise, reduced vibration, and improved aerodynamic efficiency. An oscillating pitch rig and a generalized rotor aeroelastic model will be utilized in the transonic dynamics tunnel for investigation of rotor unsteady aerodynamic effects. Research on advanced tilt-rotor vehicles will include study of feedback control systems, methods of gust suppression, and handling qualities requirements. Helicopter flight tests will be carried out using arbitrarily shaped flight-paths for investigation of terminal area operating procedures, piloting techniques and handling qualities and display requirements. The dynamic characteristics of large helicopter transports which adversely affect the passengers and the community will also be investigated in flight.

During FY 1976 and the transition period, the advanced Vertical Takeoff and Landing (VTOL) aircraft program will concentrate on lift/cruise fan aircraft technology, with primary emphasis on the technology related to small lift/cruise fan vehicles that have good potential for both military and civil utility missions. Small and large scale wind tunnel tests, control system analyses and tests, large scale thrust-vectoring tests, and simulation experiments will be performed. Other efforts will include study of jet interactions and exploratory research on promising VTOL fighter-type vehicles.

In the area of powered-lift aircraft technology, in FY 1976 and the transition period, research on advanced upper-surface blowing (USB) concepts employing attached flow over the wing to achieve high lift will be emphasized. Large scale wind tunnel tests will provide aerodynamic data, and static tests will provide aerodynamic turning, acoustics, and loads information. The cruise

performance of advanced USB configurations will also be investigated in the 16-foot transonic wind tunnel. Study of advanced augmentor-wing concepts, including large scale tests of an improved nozzle and an acoustically treated augmentor will be carried out. A combined analytical, simulation and flight research program to provide data for revision and extension of existing handling qualities criteria for powered-lift Short Takeoff and Landing (STOL) aircraft will continue.

High-Speed Vehicle Aerodynamics and Flight Dynamics Research and Technology

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$7,932	$9,100	$8,900	$8,830	$2,500

OBJECTIVES AND STATUS

The high speed aerodynamics program is directed toward generating advancements in design and prediction techniques for economy, safety, and reliability in civil aircraft and superiority in military aircraft.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The funding change reflects (1) the deferral of study and experimental efforts on active cooling systems for hypersonic aircraft until the hypersonic vehicle program can be better defined with the Air Force, and (2) cost savings realized by the successful completion of the F-15 RPRV stall/spin program ahead of schedule.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

During FY 1976 and the transition period in the area of medium and long haul cruise aircraft aerodynamics, design information will be provided through evaluations of promising concepts on transport configurations. Numerous concepts such as compliant skin, oblique-wing, supercritical wing, and winglets will be parametrically evaluated for exploitation on future cruise aircraft such as a fuel conservative transport. Evaluation of the oblique wing concept through facility tests, simulation, and parametric studies through spring 1975 will lead to a large (850 pound) radiocontrolled remotely piloted flight test by summer 1975. If the studies and early flight results substantiate the promise of the oblique wing concept, transonic flight tests will be programmed for a modified Firebee II vehicle.

In the area of new aerodynamic technology for increased combat effectiveness of fighters and missiles, in FY 1976 and the transition period, numerous concepts will be applied to improve efficiency in terms of increased range, maneuverability, and controllability. The vectoring in forward flight (VIFF) maneuvering technique, proven on Kestrel aircraft, will be evaluated on the improved Harrier Drop tests utilizing the 3/8-scale F-15 Remotely Piloted Research Vehicle (RPRV) to successfully and safely substantiate the stall, spin and recovery predictions of the spin tunnel will be completed by mid-CY 1975. Opportunity to compare RPRV results with F-15 aircraft results will be explored for further substantiation of predictive techniques. The aerodynamic influences of installed propulsion systems on fighter and other high speed aircraft will be investigated and promising beneficial interactions will be pursued for advanced configurations.

During FY 1976 and the transition period, in the area of hypersonic aerodynamics, representative configurations will be studied and tested to establish a technology base to extend predictive techniques to future applications.

In the area of Department of Defense (DOD) assistance, in FY 1976 and the transition period, experimental, consultative and other technical assistance will continue on major development programs such as B-1, F-14, F-15, ACF, and others as identified by DOD in future requests.

Aeronautical Man-Vehicle Technology

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
		(In Thousands of Dollars)		
$3,675	$4,800	$4,800	$5,030	$1,400

OBJECTIVES AND STATUS

The aeronautical man-vehicle technology program provides a research and technology base for providing solutions to the human problems impeding the growth and safety of air transportation. Major foci are to understand the relationships between aircraft noise and human response and to enhance the safety, economy, and effectiveness of new air transportation systems through development of automated flight management cockpit technology.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

In the area of aircraft noise, a multidisciplined group of scientists are developing laboratory measures and subjective response scales to define individual response to aircraft noise. In addition, field research is being

conducted to coincide with developed laboratory hypotheses so that transfer functions and algorithms can be developed. In FY 1976 and the transition period, preliminary studies will be concerned with number of flights, aircraft mix, time of day, directionality, landing versus takeoff, activity disruption and background noise.

Human response to interior noise, aircraft vibration, motion and other factors shaping attitudes towards the National Air Transportation System, i.e., technological advancements (Vertical Takeoff and Landing, Short Takeoff and Landing and supersonic cruise aircraft), are being analyzed from the standpoint of passenger acceptance and ride quality. Resulting data are being used to form a scientific information system of subjective response to specific vehicle ride characteristics. In FY 1976 and the transition period, contours of equal comfort will be developed along with studies to interpret effects of combined noise and vibration, frequency masking, sensitivity to and discomfort from vibration, and multimodal transportation systems.

In the area of flight management, a research program is being pursued to address the growth implications of civil aviation in the 1980-1990 period of automated flight systems. Anticipation of continued complexity of the airspace operating requirements is manifest in the conception and continued introduction of new control and display systems into the aeronautical world. Such systems tend to complicate and/or increase crew workload. To reap the benefits of the new systems and technologies the total cockpit system must be completely understood. In FY 1976 and the transition period, the human factors engineering techniques and methodologies will be used to develop the required cockpit configuration for the 1980's and demonstrate the safety, economy, and effectiveness of computer-based, automated cockpit systems.

In the area of simulation technology, a multifaceted program is underway to determine simulation fidelity requirements, and to develop and validate methods of effectively simulating the full range of aeronautical tasks performed in the cockpit. In FY 1976 and the transition period, studies will continue in the area of visual display requirements, techniques for using color digital systems, motion cue requirements and the investigation of methods of measuring pilot performance in simulation/flight environments.

Systems Studies

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$3,100	$3,000	$3,000	$3,000	$700

OBJECTIVE AND STATUS

The overall program objective of aeronautical systems studies is to determine the technology requirements, costs, benefits and impacts of advanced civil and military aeronautical systems based on mission, systems and conceptual studies. Advanced aeronautical concepts are identified, analyzed and evaluated.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The System Studies program presented in this budget has been restructured from the program appearing in last year's budget under the same title. Many of the studies justified here last year are now part of the Systems Technology Programs justification material. For comparison purposes, this change has also been shown in the FY 1974 and FY 1975 Budget Estimate columns.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

In the FY 1976 and the transition period, civil air transportation systems studies will be conducted to identify technology requirements, evaluate concepts and tradeoffs, and clarify National needs in support of improved near-term and future civil air transportation systems, including both commercial and general aviation.

Studies will also be conducted during FY 1976 and the transition period to identify technology requirements and evaluate concepts and tradeoffs in support of future military aviation systems, coordinating closely with the Department of Defense in their identification of future military needs and missions.

With respect to both civil and military applications, studies will be conducted, during FY 1976 and the transition period, to identify and evaluate promising approaches for reducing the fuel/energy consumption of future aviation systems.

Systems analysis methods for program assessment will continue to be developed and implemented as routine elements of the budget formulation process. In addition, studies examining alternatives for future overall program direction will be executed during FY 1976 and the transition period.

Systems Technology Programs

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(In thousands)			
Materials and structures systems technology	$1,000	$3,400	$3,400	$8,100	$4,400
Propulsion systems technology	---	500	500	2,500	1,200
Avionics systems technology	1,220	4,100	4,100	6,000	2,000
Aircraft operating systems technology	14,975	12,250	12,250	11,900	2,600
Aerodynamic vehicle systems technology	860	3,350	3,350	4,650	1,200
Advanced civil Aircraft systems technology	7,146	7,300	7,300	12,500	4,300
Man-vehicle systems technology	---	---	---	200	100
Military aircraft systems technology	1,150	800	800	700	---
Total	$26,351	$31,700	$31,700	$46,550	$15,800

Materials and Structures Systems Technology

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$1,000	$3,400	$3,400	$8,100	$4,400

OBJECTIVE AND STATUS

The objective of this effort is to accelerate the transfer of advanced materials and structures technologies to application in design of airframe structures and engines. Accomplishment of the objective involves development of prototype components for laboratory testing and long term operational service evaluation, and, where necessary, development of more efficient analysis and design techniques.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The Materials and Structures Systems Technology program is a new budget structure category. The resources shown in FY 1975 reflect the Composite Primary Structures program, the Integrated Programs for Aerospace Vehicle Design effort and the Materials for Advanced Turbine Engines program. In FY 1974 this category consisted of the Composite Structures Flight Experiments program. For comparative purposes this change has been shown in both the FY 1974 and the FY 1975 Budget Estimate column.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

The Composite Primary Structures program was initiated in FY 1975 to demonstrate a 25 - 30 percent weight saving through the application of composite materials in primary structural components of commercial transport aircraft, and to establish confidence in the economy, durability, and maintainability of composites through actual flight service. This effort will be conducted through contracts with manufacturers of commercial airliners. It will include design and manufacture of a tail and wing component. The contract for the tail component is being initiated during FY 1975. The wing development will be initiated early in FY 1976. Each contract will include engineering development, design, test, Federal Aviation Agency (FAA) certification, and installation on a scheduled airline aircraft to replace a standard metal component. This will be accomplished in about 5 years followed by a 5-year flight service evaluation during which each component is expected to accrue approximately 15,000 hours of flight service.

The Integrated Programs for Aerospace Vehicle Design (IPAD) was initiated in FY 1975 to provide a computer software system that will significantly aid the vehicle design process by automating and integrating many of the time-consuming functions now required of the design staff. Preliminary studies have established the feasibility of the system and have indicated that savings in design cycle time and cost of 50 percent could be achieved. The system development will provide: (1) an executive program to interface with the user and control the rest of the system; (2) utilities programs which provide computer language translation, report writing, control of interactive graphics, etc.; and (3) a data base manager program to control the huge catalog of technical data required for vehicle design. The FY 1976 and transition period effort will continue activities on these elements leading to completing an operational system by FY 1980.

The Materials for Advanced Turbine Engines (MATE) program is aimed at determining the potential of new high technology materials for use in advanced aircraft turbine engines. The potential will be demonstrated by, accumulating engineering property data, and performance testing in rigs and in ground test engines. This rapid accumulation of engine experience will allow accelerated realization of an additional 5 percentage points of return on investment when the materials are used in advanced commercial aircraft. This effort is being

initiated in FY 1975 with the first material probably being an advanced superalloy blade material having a 75 degree Farenheit increase in temperature capability In FY 1976 the second material will be selected and will probably be a powder metallurgy disk alloy with potential of having three times longer life than cast or forged disks, and a 40 percent reduction in manufacturing cost.

A new activity, the Aeroelasticity of Turbofan Engines Program is being initiated to improve capability for understanding and avoiding aeroelastic instability in turbine engine fan blades. This is a joint research effort with the Aero Propulsion Laboratory of the United States Air Force. In FY 1976 and the transition period, the NASA effort will involve initiation of fan flutter tests, analytical and experimental studies of aeroelastic factors, and research on aero-mechanical coupling. The joint activity is aimed at providing advanced design and test methods for coping with increasingly critical engine aeroelasticity problems by FY 1979.

The Fire-Resistant Materials Engineering Program will be aimed at the development of fire-resistant, low toxicity materials for use in aircraft interiors, windows, and insulation for fuselages, fuel lines, and engine nacelles. In FY 1976 and the transition period work will begin on the synthesis and development of polymeric interior materials, high impact windows, and insulations based on char forming mechanisms. Work will be done to improve the fire safety of fuel lines and engines. Basic polymer rheology understanding will be applied to developing anti-misting fuels. An effort will be made to modify existing materials to improve fire resistance and a 737 fuselage will provide the test bed for systems testing. This is a three-year program with the aim of providing a full scale aircraft systems test in FY 1978.

Propulsion Systems Technology

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
---	$500	$500	$2,500	$1,200

OBJECTIVE AND STATUS

The aeronautical propulsion systems technology programs will demonstrate advancements in technology through system design and test of subassemblies incorporating results of advanced component research. Improved engine development, environmental effects or a combination of these parameters are the criteria governing systems technology programs.

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CHANGES FROM FY 1975 BUDGET ESTIMATE

The Propulsion Systems Technology program is a new budget structure category. The resources shown in FY 1975 reflect the Advanced Multistage Axial Flow Compressor program.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Compressors are recognized to be the pacing item in turbofan engine development programs. It appears possible from the results of research undertaken by NASA that a single spool axial flow compressor can develop a pressure ratio of 20 to 1 in as few as 6 stages compared to 13 stages in current technology compressors. Reductions of up to 20 percent in aircraft gross weight with significant reductions in fuel consumption and operating costs may be achieved as a result of this work. Initial program activity in the Advanced Multistage Axial Flow Compressor program began in FY 1975 with conceptual design study contracts awarded to two contractors. Completion of the study contracts will occur early in FY 1976. On the basis of these studies a single contractor will be selected in FY 1976 to design, fabricate and test the experimental compressor.

The energy crisis is one of the most far-reaching problems besetting the airline industry. The NASA Advanced Energy Conservative Turbofan Systems Technology Program includes many work elements related to energy conservation. It is estimated that by incorporation of appropriate advanced components and subassemblies resulting from NASA research into an advanced turbofan engine, as much as a 30 percent reduction in cruise fuel consumption may be attained, compared to present generation turbofan engines. Studies initiated during FY 1975 are examining unconventional, low energy consumption engine concepts which may include regenerators, intercoolers, and variable area turbines. These studies will be extended in FY 1976 and the transition period to identify specific systems technology experimental investigations of unique component and propulsion subassemblies. One or more contractors will be competitively selected in FY 1976 to conduct the experimental investigations of unique components and propulsion subassemblies identified in the extended studies.

The enlarging fleet of jet powered general aviation airplanes requires that some attention be devoted to the environmental problems of noise and pollution due to this segment of aviation. Previous NASA efforts have demonstrated significant noise suppression and emission reduction technology on large engines. However, a significant portion of the NASA technology had been conducted with low noise fans and clean combustors of a size representative of general aviation turbofan engines. The Quiet, Clean General Aviation Turbofan program, a 4-year systems technology program beginning in FY 1976, will demonstrate the low noise and clean combustor technology in a turbofan engine of less than 5,000 pounds of thrust. Studies have been initiated during FY 1975 to define the systems technology program to be followed by a contract award in FY 1976 for engine design fabrication and test. Program costs will be kept

at a minimum by extensive use of existing engine component technology and by use of existing engine cores requiring no major modifications, except for those parts bearing directly on noise or emissions experiments. There is no intention to carry the engine into a preprototype, development or production program. Cost sharing will also be explored to keep program costs at a minimum.

Avionics Systems Technology

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(In Thousands of Dollars)		
$1,220	$4,100	$4,100	$6,000	$2,000

OBJECTIVES AND STATUS

The avionics systems technology program applies the fundamental knowledge gained in the Research and Technology Base to develop and demonstrate the technical readiness and encourage the transfer of advanced systems to the aircraft industry through experimental testing and verification in a realistic environment.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The Avionics Systems Technology program is a new budget structure category. The resources shown in FY 1975 reflect the Fly-By-Wire Flight Experiment program, the General Aviation Low Cost Avionics program and the Active Control Aircraft Flight Experiment program. In FY 1974, the resources reflect the Fly-By-Wire Flight Experiment program.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

The Fly-By-Wire program will provide an all electronic, redundant aircraft flight control system to be used for a feasibility demonstration, and to evaluate shuttle software concepts and advanced transport control laws in a representative environment. The principal emphasis is on reduced weight and fuel consumption, and on improved performance and operational flexibility. The final design review of the triplex, fully redundant, all digital Fly-By-Wire system is scheduled for May 1975 with the first flight scheduled for FY 1976.

The General Aviation Advanced Avionics program, aimed at providing a totally integrated advanced, low cost avionics system to enhance the safety, reliability, and utility of future general aviation aircraft will be designed and demonstrated. Data from inital design studies, scheduled for completion in

FY 1976, will be used to define candidate configurations and to delineate subsystem requirements. Preliminary system specifications and requirements will also be derived during FY 1976 and the transition period. Critical avionics components for these subsystems will then be developed and evaluated during representative flight tests to ensure their feasibility and performance.

Under the Active Control Aircraft program, studies on the concepts of reduced static stability and gust and maneuver load alleviation for active control will be completed during FY 1976 for incorporation into an Active Control Analysis Computer Program. A contract for the integrated design of a long haul subsonic transport using these concepts will also be completed in FY 1976. The resultant active control aircraft configuration will then be extended to include flutter suppression and will be flight tested on a special research vehicle during FY 1980 and 1981. Concurrently, an active control system stressing ride quality improvement will be developed and flight tested on a short haul Twin Otter aircraft during FY 1976, the transition period and FY 1977. An expanded version of this system, including additional active control concepts such as gust and maneuver load control, and flight path control, will be designed and evaluated by FY 1978.

Aircraft Operating Systems Technology

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$14,975	$12,250	$12,250	$11,900	$2,600

OBJECTIVES AND STATUS

This program will provide proven system concepts, technology, operational flight procedures and techniques on which logical decisions can be based for improvements in airborne systems (avionics and air vehicle) which will solve the interface problems between the aircraft and its operating environment. It concentrates on the terminal area performance characteristics of aircraft to increase air traffic system productivity within the constraints of safety, passenger comfort, pilot workload, community noise and emissions, and minimum time and fuel expenditures.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The Aircraft Operating Systems Technology program is a new budget structure category. The resources shown in FY 1974 and FY 1975 reflect the Operating Systems Experiments program plus a portion of the Systems Studies and Design Studies programs. For comparison purpose this change has also been shown in the FY 1974 and FY 1975 Budget Estimate columns.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

In System Technology Studies, FY 1976 and the transition period efforts will include definition and quantification of acceptance factors for short haul air travelers; investigation of area navigation techniques for flying direct terminal-to-terminal routes at low altitudes; establishing small community user requirements for microwave instrument landing systems; and analysis of flight data to identify potential accident causing factors.

The Terminal Configured Vehicle Systems, research will continue in FY 1976 and the transition period with a small contemporary jet aircraft, to provide technology for assuring compatability and safety of advanced conventional jet transport aircraft in future high density terminal area environments. Experiments with a digital autoland system in combination with a microwave instrument landing system will be commenced in FY 1976. A flight evaluation of curved, decelerating, and other types of noise reduction flight procedures will be completed in FY 1976.

In the Short Takeoff and Landing (STOL) Operating Systems program, a related effort is being conducted for short takeoff and landing aircraft under a joint agreement with the Federal Aviation Agency (FAA) to develop a data base for use by industry and government in establishing systems criteria and operational procedures. Flight experiments will be conducted in FY 1976 using an augmentor wing jet STOL research aircraft and a modified Twin Otter equipped with an advanced integrated digital avionics systems with sufficient capability and flexibility to investigate system configurations and define methods by which STOL aircraft can be operated effectively and safely in air traffic environments of the 1980-1990 time period.

In the Vertical Takeoff and Landing (VTOL) Operating Systems program, a technology base is being established for VTOL aircraft which will provide the capability to land and takeoff with optimized fuel consumption and safety while at the same time enabling operations in foul weather conditions from a wide variety of landing sites. Flight experiments with helicopters will continue in FY 1976 and the transition period and flight research with nonrotary wing VTOL research aircraft is planned for FY 1977.

Aerodynamic Vehicle Systems Technology

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$860	$3,350	$3,350	$4,650	$1,200

OBJECTIVES AND STATUS

This program is focused primarily on flight evaluation and demonstration of selected aerodynamic concepts directed at improving aircraft performance, efficiency, safety, handling qualities, maneuverability and other important aircraft characteristics while at the same time striving to improve overall operations in regard to factors such as fuel consumption, community acceptance, and direct operating cost.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The Aerodynamic Vehicle Systems Technology program is a new budget structure category. The resources shown in FY 1975 reflect the Wake Vortex Flight Minimization Flight Research program, the Rotor Systems for Rotor Systems Research Aircraft program, and the C-8 Augmentor Wing Flight Experiment program. In FY 1974, the resources reflect the C-8 Augmentor Wing Flight Experiment program and a portion of the Design Studies program. The C-8 program will be completed in FY 1975.

BASIS FOR FY 1976 AND TRANSITION PERIOD ESTIMATES

To guide the selection and definition of aerodynamic concepts for focused laboratory and flight evaluation, Systems Technology Studies are conducted to provide integrated design assessments of promising concepts in aircraft applications. These studies in FY 1976 and the transition period will include preliminary design of an advanced lift/cruise fan propulsion system and an assessment of the relative utility of lift fan, tilt rotor and advanced helicopter aircraft for a range of civil missions.

The Wake Vortex Minimization program will continue in FY 1976 and the transition period to develop and demonstrate aerodynamic methods to reduce the landing and takeoff separation distance imposed by wake vortices generated by large jet transports on trailing aircraft. A reduction from the present 3-5 miles separation to 2 miles is being sought without significant detrimental effects on aircraft performance. The results of ground facility and preliminary flight research in FY 1975 indicate that this goal may be feasible by utilizing techniques for changing wing lift distribution through tailored deflection of spanwise flap segments, or addition of turbulence through air injection, vortex generators and trailing devices. The effort in FY 1976 and the transition period will be focused on validating ground-based results and optimizing alleviation techniques.

In the Rotor Systems for Rotor Systems Research Aircraft (RSRA) program, improved rotor airfoils and blade tip shapes will be evaluated, and competitive contractual predesign studies completed in FY 1976 to define an advanced aero/acoustic rotor as a candidate research rotor system for future evaluation on the Rotor Systems Research Aircraft (RSRA). Dynamic model tests to investigate the aeroelastic characteristics, and contractual system design studies begun

in FY 1975 to define advanced variable-geometry and bearingless composite structure rotors for evaluation will also be completed. Major contractual efforts during FY 1976 will initiate the detailed design, fabrication and ground test checkout of two full scale flight test rotor systems for thorough evaluation on the RSRA. This rotor systems research activity is geared to exploit the potential for significantly improved military and civil helicopters in the broad areas of performance, efficiency, noise and dynamics through integrated systems technology development and flight validation.

Advanced Civil Aircraft Systems Technology

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(In Thousands of Dollars)		
$7,146	$7,300	$7,300	$12,500	$4,300

OBJECTIVES AND STATUS

The objective of this program is to provide a technology base for transport vehicles in the short haul and long haul categories with emphasis on fuel conservation, noise reduction, economics, and their interactions in aircraft design, using promising technologies generated in the research and technology base programs.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The Advanced Civil Aircraft Systems Technology program is a new budget structure category. The resources shown in FY 1975 reflect the YF-12 Flight Experiments program, the Advanced Acoustic Composite Nacelle Flight program and a porting of the Systems Studies and Design Studies programs. In FY 1974 the resources shown reflect the YF-12 Flight Experiments program and a portion of the Systems Studies and Design Studies program.

BASIS FOR FY 1976 AND TRANSITION PERIOD ESTIMATES

System Technology Studies in FY 1976 and the transition period will assess the benefits of lightweight and composite structures, modularized engine components, advanced controls, noise and emission suppression and advanced lift systems could have on future short haul transport systems. Studies will also consider the effect of improvements in short haul aircraft terminal area maneuverability on community noise and airport congestion relief. Other studies will be made to integrate drag reducing aerodynamic developments (e.g. boundary layer control, oblique wing, winglets, etc.) to define practical long haul aircraft configurations of conventional or unconventional design, with improved economics and environmental compatibility. The advantages of using improved independent power generation for onboard utilities will be explored, including their application to powered wheels and boundary layer control.

In FY 1976 the Fuel Conservative Aircraft Systems Technology program will be initiated to exploit technical opportunities to reduce fuel consumption of transport aircraft in various areas, such as: active controls, composite materials, induced and viscous drag reduction, advanced propulsion systems and advanced avionics. At present, ongoing NASA programs have progressed to a point where it is appropriate to evaluate the potential fuel savings these technical opportunities might have on a fuel conservative aircraft design. Therefore, aerodynamic and advanced control technologies, that can lead to major savings in aircraft fuel consumption, will be developed to establish a state of technical readiness for implementation on transports of the mid-1980's. Flight tests will be conducted to verify and demonstrate that the fuel conservative technologies are feasible, and that an aircraft designed with these technologies can provide for practical, economical, and safe operations.

Forecasts indicate ultimate depletion of hydrocarbon fuels and expose the need for developing alternate aircraft fuels to insure a strong, competitive U.S. Civil Aviation Industry beyond the 1990 time period. Hydrogen is an abundant energy source and offers significant advantages as an aircraft fuel. In the Hydrogen Fueled Aircraft Systems Technology program, initiated in FY 1976, ground tests will be carried out to generate and verify the technology data base from which design requirements can be established for a safe hydrogen fueled transport aircraft. The research effort on long lead-time technology will include development of lightweight cryogenic tanks and insulation. Wind tunnel studies will determine the performance and stability characteristics of aircraft configurations with the fuel stored in wings, pods, fuselage, and booms.

New long range subsonic transport aircraft must be responsive to the demand for quieter operations. To achieve a significant reduction in the noise footprint area, without increased operating costs and fuel consumption, the Advanced Acoustic-Composite Nacelle will develop a composite nacelle for potential application to high bypass ratio engines of future transport aircraft. (Alternatively, this nacelle technology would permit a reduction in aircraft weight and fuel consumption at the expense of some of its noise reduction potential). The project will capitalize on improved methods for integrating acoustic absorbent and composite materials to form a lightweight, load-carrying structure obtimized for noise suppression. Design studies will define cost and weight-effective means of integrating various acoustic-composite material concepts in nacelle construction and include the sensitivity to noise reduction of such factors as direct operating cost, takeoff gross weight, and fuel consumption. Research on materials, structures, and noise will be performed to accrue the necessary technical base for multi-section acoustic duct liner design.

Variable-cycle engines show great promise for efficient operation of supersonic transport aircraft. Propulsion systems studies have identified several potential engine cycles which could, with proper component development,

provide the technology base required for a low noise, minimum pollution, economically feasible engine for a supersonic transport. In the Variable Cycle Engine Component System Technology program, initiated in FY 1976, the common components already identified such as diverter valves, variable inlets and nozzles, secondary burners, etc., would be designed, developed and tested. Studies will integrate the engine component technology data into the most likely candidate cycle for a possible future experimental engine program.

The YF-12 aircraft is the only United States aircraft that can be used for flight research in the Mach number range above 2.7. Propulsion systems, stability and control, structures, and aerodynamic experiments are conducted and compared with analytical studies and the results of wind tunnel and ground tests. In FY 1976 in the YF-12 Flight Experiments program, steady state and dynamic inlet performance data will be analyzed and compared with wind tunnel inlet test data. In the stability and control area, a cooperative control system will be flight tested and the lateral control and inlet shock stabilization system activities will begin to be programmed into the YF-12. Titanium honeycomb, boron-aluminum panels will be tested and resin and metal matrix panels will be installed for their initial flight tests. A cold wall hollow cylinder will be carried to high speed to establish the correlation of flight boundary layer temperatures/skin temperatures with similar measurements made in wind tunnels. The aircraft will also be used in support of the stratospheric emission impact studies and further work will define the effect of combined heating and loading on the calibration procedures for measurement of aerodynamic loads in flight.

To bolster the technology base in hypersonics, the Hypersonic Research Systems Technology program will be initiated in FY 1976 to conduct the ongoing activities in propulsion, structures, and aerodynamics that are to be augumented by experiments which could be carried on an X-24C type airplane. Studies, to be conducted jointly with the Air Force, will define an X-24C configuration with the capability of sustained flight for at least 30 seconds at Mach numbers above 6.5 and a payload bay of sufficient volume to carry instrument packages, structural experiments and the liquid hydrogen tank for a scramjet engine. Propulsion technology aspects will be directed toward developing and testing hot engine components. Structures technology will be directed toward the experimental evaluation of hot, actively cooled structures and fuselage liquid hydrogen tanks, which could lead to the development of the experimental packages for a research vehicle. The aerodynamics aspects are directed toward support of the X-24C activity and to develop the required scramjet/airframe integration.

Man-Vehicle Systems Technology

	1975			
	Budget	Current		Transition
1974	Estimate	Estimate	1976	Period
	(In Thousands of Dollars)			
---	---	---	$200	$100

OBJECTIVES AND STATUS

The aeronautical Man-Vehicle System Technology program is designed to reduce the incidence of approach and landing accidents attributable to human error and to develop technology and operational procedures that will insure optimum crew coordination in multipilot aircraft.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

The aviation community, both national and international has expressed major concern over human errors in air transportation. This concern covers the following areas of human factors: (1) aircrew safety awareness; (2) aircrew discipline; (3) cockpit discipline, (4) flight crew management and flight operations. The focus of these areas centers primarily on Approach and Landing Safety. The focus of the Approach and Landing Safety program in FY 1976 and the transition period will be to identify and investigate potential solutions to offset the increase in "human error"--caused commercial aircraft accidents. The program will be fully coordinated with industry and other appropriate agencies. A classification model for accident analysis will be developed for investigation of human factors elements in aircraft accidents or incidents and to isolate factors contributing to pilot or flight crew error. Strategies to minimize pilot error will be evaluated through crew role modification and flight simulation. Validation of proven concepts will be made through observation and monitoring pilot behavior. The full mission simulation capability being developed at Ames Research Center will be used to analyze mission profiles developed to test pilot error flight profiles, as well as those developed to eliminate pilot error and adverse flight crew interactions.

Military Aircraft Systems Technology

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$1,150	$800	$800	$700	---

OBJECTIVES AND STATUS

This program provides the means of enhancing and fostering new aeronautical technologies, especially applicable to military needs, through cooperative and joint programs between the various agencies of the Department of Defense and NASA. These aircraft and missile technologies are validated through flight testing and supported by wind tunnel model tests.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The Military Aircraft Systems Technology program is a new budget structure category. The funding in FY 1974 and FY 1975 reflects the Transonic Aircraft Technology Experiments program.

BASIS FOR FY 1976 AND TRANSITION PERIOD ESTIMATES

An ongoing effort in Transonic Aircraft Technology program will provide proof-of-concept of supercritical airfoil technology in the transonic and low supersonic flight regimes and provide design criteria. This joint United States Air Force/NASA program will conduct flight testing on an F-111A equipped with a set of supercritical wings especially designed and manufactured for high maneuverability in the high subsonic regime. Tests will evaluate such parameters as buffet onset, profile drag, maximum speed, turn performance, etc. The behavior of the F-111A variable swept wing high lift devices, maneuverability, and pilots tracking ability will be established. Flight test data will be reduced and correlated with wind tunnel test data in order to generate design criteria and for establishing the general performance improvement of the basic F-111A aircraft equipped with the supercritical wings. The flight test program will be completed late in FY 1976.

Experimental Programs

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Highly maneuverable aircraft technology	---	$1,500	$1,500	$4,900	$1,800
Quiet, clean, short haul experimental engine	$6,000	10,000	10,000	10,000	2,000
Refan program	19,545	1,000	1,000	---	---
Supersonic cruise aircraft research	10,100	8,900	8,900	8,900	2,000
Tilt rotor research aircraft	5,345	11,300	11,300	1,900	300
Rotor systems research aircraft	5,266	7,100	7,100	3,100	---
Quiet propulsive lift technology	12,300	8,000	8,000	11,900	400
Total	$58,556	$47,800	$47,800	$40,700	$6,500

Highly Maneuverable Aircraft Technology

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
---	$1,500	$1,500	$4,900	$1,800

OBJECTIVES AND STATUS

The objective of this program is to provide low cost flight research vehicles to promote and stimulate the application of new high risk (laboratory) technology in a multidisciplinary manner to exploit the potential of new technology for the design of future military combat vehicles. Reductions in the cost of the experimental flight tests to explore the new technology of approximately 50 percent over comparable manned test vehicles will be realized through flight test of subscale vehicles utilizing the relatively new Remotely Piloted Research Vehicle (RPRV) test technique.

In a recent study conducted under the auspices of the Aeronautics Panel of the Department of Defense (DOD)/NASA Aeronautics and Astronautics Coordinating Board (AACB), it was concluded that "substantial improvements will be needed for advanced fighters in the 1980's." The NASA HiMAT program is designed to respond to the identified needs by maturing through testing in the real and dynamic environment of new technologies for potential incorporation in fighter aircraft in the 1980's.

Design feasibility studies were completed in August 1973. Based on the encouraging results of the feasibility studies, follow-on conceptual design studies were conducted and completed in November 1974.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

One of the three firms participating in the conceptual design studies will be selected in late FY 1975 to carry his configuration into final design and then to fabricate two subscale unmanned flying models which will be tested at NASA's Flight Research Center using the remotely piloted flight-test technique. Preliminary design and initiation of final design of the subscale research vehicles will be accomplished during FY 1976 with completion of final design scheduled for the second quarter of FY 1977.

Quiet, Clean, Short Haul Experimental Engine (QCSEE)

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$6,000	$10,000	$10,000	$10,000	$2,000

OBJECTIVES AND STATUS

The objective of this 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 environmental technology will concentrate on obtaining low propulsion system noise (95 Equivalent Perceived Noise Pressure Level (EPNdB) noise footprint area less than 0.5 square miles or 95 EPNdB at 500 feet sideline) and low exhaust pollutants. Advanced technology is in the areas of very high bypass ratio engines, variable pitch fans, reduction gearing, composite fan blades and engine/nacelle structures, thrust reversing, and digital electronic engine controls. A contract was awarded December 1973 to the General Electric Company for the QCSEE development program.

BASIS FOR FY 1976 AND TRANSITION PERIOD ESTIMATES

The technical plan includes a critical design review of the "under-the-wing" propulsion system in January 1975 and the "over-the-wing" in July 1975. Upon approval of each design, the fabrication and assembly of components/propulsion systems will be initiated. Following completion of fabrication and assembly, the two propulsion systems will undergo a series of tests by the contractor to demonstrate structural integrity and capability to meet performance testing with appropriate powered-lift wing sections. The "under-the-wing" propulsion system will be delivered during the Transition Period. Approximately 56 months total program duration is planned including engineering support for tests at NASA for a period of about 12 months after delivery of the propulsion system.

Supersonic Cruise Aircraft Research

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$10,100	$8,900	$8,900	$8,900	$2,000

OBJECTIVES AND STATUS

This program will provide the technology for future civil and military supersonic cruise aircraft by means of an integrated program in the key areas of propulsion, structures, aerodynamics, and stability and control. The research will assess the environmental and economic impacts of new supersonic aircraft and provide data for future decisions relative to the development of this type aircraft by the United States.

BASIS FOR FY 1976 AND TRANSITION PERIOD ESTIMATES

Noise and pollution are major factors impacting the design of supersonic transports. A variable cycle duct-heating turbofan engine concept promises to reduce noise and pollution. Current static tests of duct-heating turbofan suppressor nozzles will be extended in FY 1976 to establish the effects of forward velocity on acoustic performance. Ultralow emission studies will be complemented by the application of the emission reduction techniques to a duct-heating augmentor in FY 1976. The inlet shock stabilization system, developed to provide inlet tolerance to flow disturbance at very high speeds, will be modified in FY 1976 for eventual test on the YF-12.

Major reductions in structural weight are required for economical, supersonic cruise aircraft. Fatigue, fracture, flutter and lifetime characteristics of structures under the severe environment of supersonic flight must be addressed. Structural design studies for efficient arrow-wing concepts will be used to identify a typical wing section for test in FY 1976. Composite resin and metal matrix panels will be fabricated and tested for fatigue characteristics and then flight tested on the YF-12. Studies on a low speed model will be extended in FY 1976 to determine the applicability of active control systems for flutter suppression.

Wind tunnel tests of aircraft configurations will be conducted to improve cruise efficiency and noise reduction. These and other advanced configuration tests will assess the tradeoffs (technical, environmental, and economic) of using various variable-cycle engines. Improved analytical methods for aerodynamic design will be further developed in FY 1976 and the transition period for validation in FY 1977. By FY 1979, these developments are expected to provide a 30-percent improvement in lift-to-drag ratio.

Problems at high Mach numbers will be studied by flight testing a new control system and developing an engine inlet shock stabilization system.

Stratospheric emissions impact research will be continued in FY 1976 and the transition period to measure, with new sensitive instrumentation, the natural atmospheric constituents and the near-wake chemistry of the YF-12. The instrumentation will detect constituents which affect ozone production and decay to provide the basis for monitoring the upper atmosphere.

Tilt Rotor Research Aircraft

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(In Thousands of Dollars)		
$5,345	$11,300	$11,300	$1,900	$300

OBJECTIVES AND STATUS

This joint NASA/Army program will provide proof-of-concept and perform advanced flight research investigations utilizing two tilt rotor research aircraft presently being designed and fabricated as part of this program. A primary objective of this program is to evaluate the potential benefits of applying tilt rotor technology, developed over the last twenty years, to various Army, Air Force, Navy and commercial missions which require the unique capabilities of the tilt rotor concept.

The low downwash and low noise inherent in rotors provide valuable benefits for military rescue missions and ground attack missions where short detection time is important to survival in a hostile arena. For civil applications, the efficient Vertical Takeoff and Landing (VTOL) capability will permit operations at small airfields and close-in populated areas to provide an efficient transportation system. The tilt rotor VTOL capability eliminates the need for taxiing and maneuvering on the ground and the attendant use of valuable fuel. The inherent efficiency of the rotors acting as propellers in cruise can provide an effective, fuel saving, public transport system for short and intermediate ranges. The tilt rotor research aircraft will have twice the cruise speed of the helicopter while retaining its efficient hover capability. Based on in-house studies and analyses by NASA/Army engineers, it has been concluded that the tilt rotor concept shows the greatest promise for a capability to meet military and civil Vertical/Short Takeoff and Landing (V/STOL) needs anticipated in the future.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

A preliminary design competition was conducted in early FY 1973. Bell Helicopter Company was awarded a contract for the design and fabrication of two tilt rotor research aircraft in July 1973. The principle design effort was completed in December 1974. Material procurement and manufacturing will be carried on through FY 1975 and FY 1976. First flight is scheduled for early FY 1977.

Rotor Systems Research Aircraft

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$5,266	$7,100	$7,100	$3,100	---

OBJECTIVES AND STATUS

This joint Army/NASA program will provide a unique flight test capability for advanced rotor research to expedite and improve rotorcraft research through the use of a specially designed flight test vehicle.

Extensive onboard instrumentation will provide better research data, and repeated use of the test vehicle will enable timely and economical completion of rotor research projects.

Currently, flight tests of promising advanced rotor concepts are conducted by modifying existing aircraft or by building a new aircraft for each concept. This approach is time consuming, costly, and often gives less than good results.

BASIS FOR FY 1976 AND TRANSITION PERIOD ESTIMATES

NASA and Army in-house and contractor predesign studies were conducted in early FY 1973 to establish the feasibility of an advanced research vehicle capable of testing a wide variety of advanced rotor systems concepts, and to define the characteristics of and requirements for the flight vehicle, the flight test control system, and the research instrumentation systems. A contract was awarded to Sikorsky Aircraft Company in November 1973 for the design and fabrication of two aircraft. Detail design and component fabrication began in January 1975. Design of the aircraft will be completed in FY 1975. Fabrication will continue in FY 1976 with first flight scheduled for late FY 1976.

Quiet Propulsive Lift Technology

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$12,300	$8,000	$8,000	$11,900	$400

OBJECTIVES AND STATUS

The Quiet Propulsive-Lift Technology program will generate and verify through ground-based and flight research a technology data base for design and certification criteria for practical and efficient quiet propulsive-lift short haul transports. The program consists of: (1) an effort directed to flight research utilizing the Air Force Advanced Medium Short Takeoff and Landing (STOL) Transport (AMST) prototype aircraft; and (2) an effort directed to flight research utilizing a Buffalo aircraft modified at low cost into a Quiet Short Haul (propulsive-lift) Research Aircraft (QSRA).

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

In the AMST program, NASA participation involves taking maximum advantage of both the Boeing and Douglas AMST aircraft to accomplish part of the Quiet Propulsive-Lift Technology program objectives. In FY 1975 NASA is continuing to provide extensive simulator support to the AMST control system development, initiating installation of NASA flight research instrumentation in the AMST aircraft, and participating in the Air Force flight test planning through membership of the NASA Deputy Test Director on the Joint Test Team. In FY 1976 and the transition period, NASA will participate in the Air Force flight evaluation of the AMST and provide support for the conduct of the NASA research experiments. In FY 1977 NASA will take the lead for potential extended flight research investigations including the possibility of modifying the AMST aircraft. Stability, control, aerodynamic performance and handling qualities will be measured to the limit of the AMST capability.

The Quiet Short Haul Research Aircraft (QSRA) effort involves low cost modification of an existing Buffalo aircraft into an aircraft which has greater flight research capability than the AMST aircraft. The aircraft will be modified to a four-engine swept-wing advanced hybrid upper surface blowing propulsive-lift configuration to obtain stability, control, aerodynamic performance, noise footprint and handling qualities flight research data. In FY 1975, paralleled, preliminary aircraft design studies were completed by the Boeing Company and Lockheed-Georgia Company. In November 1974, Request for Proposals were issued for competitive procurement of final design, fabrication and flight test support of the QSRA. Contract award is scheduled for the end of FY 1975. Flight research with the modified aircraft would begin in early FY 1978 and by the end of FY 1978 NASA would provide industry and the FAA with data to establish initial certification criteria for handling qualities, operations, and noise footprints of civil propulsive-lift short haul aircraft.

RD 8-40

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE AND NUCLEAR RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Research and technology base	$60,022	$61,500	$60,500	$61,300	$18,500
Systems studies	1,300	1,600	1,600	1,600	400
Systems technology programs	1,885	2,265	2,265	2,200	800
Experimental programs	---	2,000	2,000	3,700	1,100
Low cost systems program	3,100	5,000	5,000	6,100	1,500
Total	$66,307	$72,365	$71,365	$74,900	$22,300
Distribution of Program Amount by Installation					
Kennedy Space Center	---	---	$50	$50	---
Johnson Space Center	$700	$765	75	150	---
Marshall Space Center	2,820	3,401	2,310	2,630	$700
Goddard Space Flight Center	4,650	5,222	5,656	5,470	1,200
Jet Propulsion Laboratory	13,555	13,912	16,215	15,820	4,900
Wallops Flight Center	---	---	61	50	---
Ames Research Center	6,984	7,390	9,073	8,520	2,600
Flight Research Center	1,300	1,128	1,000	950	300
Langley Research Center	13,154	15,920	14,667	18,320	5,900
Lewis Research Center	19,859	22,716	19,492	20,380	6,000
Headquarters	3,285	1,911	2,766	2,560	700
Total	$66,307	$72,365	$71,365	$74,900	$22,300

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE AND NUCLEAR RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION

The objective of the Space and Nuclear Research and Technology program for FY 1976 and the transition period is to provide a technology base which will adequately support current and future space activities involved in the exploration and exploitation of space. The program concentrates on advancing the technologies used in systems required to transport, protect, power, control and communicate with the spacecraft and scientific instruments needed to achieve the objectives of current and future NASA space missions. Much of the basic technology developed in the program is applicable to a broad range of terrestrial problems in fields such as energy and communications.

CHANGES FROM FY 1975 BUDGET ESTIMATE

In May of 1974, NASA established the new Office of Energy Programs and consolidated under it the energy related functions previously performed by other NASA Program Offices. In the current budget, these programs are all reflected under the Energy Technology Applications program. The major portion of the Energy and Environmental Systems Technology program was transferred from the Space and Nuclear Research and Technology program to the Energy Technology Applications program as a result of this. For comparison purposes the transferred program is not shown as part of the Space and Nuclear Research and Technology program in either the FY 1974 column or the FY 1975 Budget Estimate column.

Funding for the Research and Technology Base was reduced by one million dollars during formulation of the FY 1975 operating program. This reduction was accomplished by slowing the planned activity in the Electric Propulsion program and by reducing Shuttle support activities where prudent. These and other funding changes are discussed under the relevant sections of the program narrative which follow.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Materials and structures technology will be developed to provide advanced materials and structural concepts to reduce spacecraft weight; as well as seals, lubricants, and optical and high temperature materials for use in

the hostile environment of space and spacecraft applications. The propulsion technology effort is aimed at expanding mission capabilities by increasing propulsion systems performance and life, and at lowering propulsion system costs. The effort focuses on liquid and solid fuel chemical systems, electric powered thrusters, and on the development of nuclear propulsion technology for the future. Power technology will be developed to reduce the cost and weight while increasing the power, efficiency, life and reliability of spacecraft power systems to meet the more stringent requirements of future space missions. The generation, conversion, storage, transmission and conservation of energy are all addressed by this effort. The effort focuses on long life batteries, fuel cells, thermionic converters, isotope power sources, magnetohydrodynamic generators, gaseous fueled nuclear reactor technology and high powered lasers for power transmission. A fundamental electronics effort is aimed at providing the advanced electron devices, high resolution sensors and long life reliable circuit arrays required for low cost electronic systems. Low cost guidance and control components, advanced spacecraft navigation techniques and autonomous control systems for robot vehicles will be developed as part of the guidance and control technology effort. Technology will be advanced in the areas of transmission, reception, processing and storage of information to help meet the demands of increasingly complex space missions at lower cost with increased reliability. Aerothermodynamic technology will be developed to insure the effective design of entry spacecraft for various planetary atmospheres.

Work will also be done on the development of space laboratory research facilities and supporting technology to enable NASA and other Shuttle and Spacelab users to conduct research and technology investigations in space in an economical manner.

The structure of the Space and Nuclear Research and Technology program has been modified to reflect the logical flow of the research and technology effort. The activities carried out in the Research and Technology Base are oriented toward establishing a solid foundation embracing all of the relevant disciplines and a wellspring of ideas for advanced concepts; the System Studies activity provides a basis for decisions regarding emphasis and priorities in the Research and Technology Base program and identifies and evaluates potential applications of advanced concepts; the Systems Technology programs are technology demonstration/proof-of-concept activities for concepts which have matured under the Research and Technology Base and are ready for systems integration and demonstration; or the project definition phase of potential future Experimental Programs; and the Experimental Programs involve multidisciplinary concept demonstration and major research vehicle development.

The Space and Nuclear Research and Technology program for FY 1976 and the transition period contains a planned program augmentation in the Systems Technology programs area. This new initiative will advance the technology of high temperature composite materials. Application of these materials to spacecraft structures could result in major weight savings. The Space Technology Shuttle Payloads program has been expanded to include the development of a Long Duration Exposure Facility for possible deployment of an early Shuttle flight.

BASIS OF FUND REQUIREMENTS

Research and Technology Base

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)				
Materials research and technology	$5,703	$9,122	$8,930	$8,900	$2,700
Structures research and technology	4,733	5,400	5,350	5,420	1,600
Fundamental electronics research and technology	5,145	4,800	5,550	5,300	1,600
Guidance and control research and technology	3,059	1,900	3,170	3,400	1,000
Information systems research and technology	5,223	6,800	4,780	5,190	1,600
Chemical propulsion research and technology	8,108	7,300	7,300	8,290	2,600
Electric propulsion research and technology	5,172	4,900	4,400	4,200	1,200
Space energy systems research and technology	7,882	8,200	8,100	7,290	2,200
Nuclear energy research and technology	2,792	2,200	2,200	2,200	700
High power lasers and energetics research and technology	4,600	5,000	5,000	5,410	1,600
Entry research and technology	7,605	5,878	5,720	5,700	1,700
Total	$60,022	$61,500	$60,500	$61,300	$18,500

CHANGES FROM FY 1975 BUDGET ESTIMATE

The funding for the Research and Technology Base as a whole was reduced by one million dollars during the formulation of the FY 1975 Operating Plan. Half of this one million dollar reduction was taken in the Electric Propulsion program, while the other half was taken by reducing Shuttle support activities where prudent. These and other funding changes are discussed under the relevant sections of the program narrative which follow.

A restructuring of three of the disciplinary programs with the resulting shift in program elements and associated resources accounts for the funding changes in the three programs involved. This restructuring consisted of the transfer of the high resolution sensor effort from the Information Systems program to the Fundamental Electronics program, and the transfer of the robotics and machine intelligence effort from the Information Systems program to the Guidance and Control program.

Materials Research and Technology

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$5,703	$9,122	$8,930	$8,900	$2,700

OBJECTIVES AND STATUS

This program provides, through state-of-the art advancement materials for highly efficient, low cost spacecraft structures, thermal protection systems, and propulsion and power systems for future orbiting and planetary vehicles, and supports the development of the Space Shuttle with unique expertise and facilities. Its aim is to provide the means to reduce the costs and further improve the reliability and lifetime of all space transportation systems.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The funding change reflects a reduction in the effort on alternate Reusable Surface Insulation (RSI) for the Shuttle. This reduction was made possible by increased confidence in the behavior of the RSI which is currently planned for use on the Shuttle.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Materials Science is concerned with greater understanding of the electronic, molecular and atomic structures of materials, relating these to useful properties, and using the relationships as a guide toward obtaining new or improved materials. Studies of the surface properties of semiconductors will continue to be conducted in FY 1976 and the transition period with the goal of improving the efficiency of gallium arsenide solar cells to over 15 percent. The interaction of electrons with a polarizable organic system will be investigated in order to determine the feasibility of high temperature superconductors. The interactions of electrons with defects in dielectrics will also be studied for the purpose of improving long life microelectronics.

Graphite fiber reinforced aluminum composites promise large weight savings for advanced space transportation systems. Recent advances in coatings and processes will be utilized to advance this area in FY 1976 and the transition period. The effects of the space environment on the properties of columbium and nickel-base alloys will also be determined in FY 1976. An actuator bearing will also be evaluated at 315 degrees Centigrade for applications to advanced reentry vehicles.

The development of advanced techniques to withstand the effects of the space environment will be continued during FY 1976 and the transition period. A cryogenic heat pipe will be tested, and a second surface mirror will be evaluated for its stability for 3 years in simulated synchronous orbit. Cleaning procedures will also be assessed for their effectiveness on decontaminating optical surfaces.

The program will continue to provide the technology in FY 1976 and the transition period to improve the reliable Thermal Protection Systems (TPS) for the Space Shuttle, advanced earth orbital spacecraft and planetary probes. The effect of salt spray and other contaminants on Reusable Surface Insulation (RSI) for the Space Shuttle will be completed. The evaluation of the thermal performance of Shuttle heat shield materials will also be completed. Improvements in RSI technology will continue to be pursued by modification of fiber composition, use of new coatings and optimization of processing parameters with a long range target of 1,600 degrees Centigrade (^{o}C) capability. The Venus probe heat shield design will be experimentally verified in a simulated Venus entry environment.

Structures Research and Technology

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$4,733	$5,400	$5,350	$5,420	$1,600

OBJECTIVES AND STATUS

Advanced technology is being provided for structures to meet the needs of future space systems. This technology provides improved capability for systems designers to meet stringent structural weight limitations, plan for large space erectable structures, and reduce the cost of hardware qualification procedures.

CHANGES FROM FY 1975 BUDGET ESTIMATES

The funding change reflects a reduction in the wind tunnel testing of a Thermal Protection System (TPS) configuration that is no longer a candidate for use on the Shuttle.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

New concepts and materials applications will continue to be explored during FY 1976 and the transition period for large erectable space structures needed for future microwave antennas, solar arrays, and platforms. Technology activities will be completed in FY 1976 to determine the feasibility of a large (50 - 100 foot diameter) furlable deep space antenna concept. New concepts for much larger space structures will be given increased emphasis. The potential weight saving of composite pressure vessels in place of all-metal designs will continue to be explored and demonstrated in laboratory tests.

In FY 1976 and the transition period, in the area of vehicle design methods, emphasis will be given to improvements in structural analysis programs, design and testing of entry thermal protection systems, and fracture control methods. Improvements for NASA Structural Analysis Program (NASTRAN) will be continued and evaluation of Shuttle Thermal Protection System (TPS) structures in high temperature wind tunnel tests will be continued. Efforts will continue to extend fracture control methods to make possible the design of lightweight components while increasing the reliability and service life.

During FY 1976 and the transition period, space vehicle dynamics technology activities will involve verifying data and methods needed for Shuttle development and improvement of techniques for prescribing the acoustic and vibration

environments and response of payloads. Shuttle support efforts will include testing of TPS panels in thermal-acoustic environments, wind tunnel studies of flutter characteristics, advanced methods for predicting flutter margins, and wind tunnel studies of aerodynamic noise and exhaust plume effects. The dynamic response of Shuttle payloads will be investigated using payload models installed in the 1/8-scale Shuttle model. A mulitcenter coordinated program will continue to develop approaches to reduce the cost of dynamic test and analysis requirements for certifying spacecraft hardware.

Fundamental Electronics Research and Technology

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$5,145	$4,800	$5,550	$5,300	$1,600

OBJECTIVES AND STATUS

Research and technology activities in fundamental electronics provide new devices and techniques for sensing, measuring and displaying information, and long life electronic circuits necessary for the design and synthesis of reliable, low cost electronic systems.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The high resolution sensor effort and associated funding were transferred from the Information Systems program to the Fundamental Electronics program in FY 1975.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

New technologies and materials are being investigated to improve the resolution, sensitivity and reliability of active and passive sensing systems. In FY 1976, a pulsed laser bathymeter to remotely measure coastal water depths will be flight tested. Fabrication of a tunable diode laser for measuring atmospheric constituents will be completed and flight tests initiated. Development of solid state image sensors for planetary missions will continue with emphasis on arrays of 400 by 400 elements to obtain high resolution video signals. The same solid state sensors will also be evaluated as astronomical sensors for low light level star field measurements. Acoustic sensors for predicting mechanical and structural failures in spacecraft systems will be developed and evaluated.

Research on electron devices exploits the electronic properties of materials to provide more effective and economical devices for information handling. In FY 1976, development of a 3-inch square liquid crystal display module will be completed and flight tests in an aircraft cockpit environment initiated.

An organic material now being developed for optical data storage applications will be evaluated as a holographic archival mass memory. Development of charge coupled devices for analog data processing applications will continue, and an infrared charge coupled device linear array imager will be evaluated.

Long life circuit research seeks to minimize failure rates and costs of electronic systems by developing fabrication, test and qualification techniques for large scale integrated circuit arrays. In FY 1976 and the transition period, design studies and evaluation of fabrication processes for semiconductor devices on insulating substrates will continue to increase operating speeds and reduce device size. Development of equipment and techniques to demonstrate automated design, processing and testing of large scale integrated circuit arrays will continue. Studies of failure mechanisms in integrated circuits and development of quantitative models to predict reliable operating life will continue with emphasis on insulating substrate technology for semiconductors.

Guidance and Control Research and Technology

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$3,059	$1,900	$3,170	$3,400	$1,000

OBJECTIVES AND STATUS

The space guidance and control research and technology program seeks to define and develop components and techniques which will lower the cost of spacecraft attitude control and stabilization systems, provide precise pointing of experimental payloads, increase the accuracy and efficiency of planetary navigation and guidance systems, and provide sensors and logic systems which enable the autonomous operation of unmanned vehicles in alien environments.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The robotics and machine intelligence effort and associated funding were transferred from the Information Systems Program to the Guidance and Control program in FY 1975.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

In the area of low cost control and stabilization components, efforts center on the development of improved momentum control devices and their integration with appropriate sensors and software to obtain long life, low

cost and high accuracy. In FY 1976, and the transition period evaluation of a breadboard annular momentum control device capable of 3-axis stabilization to 0.1 arc seconds will be completed and a study of the necessary modifications and software to provide experiment pointing and control initiated. Breadboarding of a video inertial pointing system for precise off-axis pointing of infrared telescopes will begin. Development of reaction wheels using magnetic suspension technology to achieve 5-10 year operating life for planetary spacecraft control systems will continue. Flight test of a laser gyro inertial reference system costing less than 50 thousand dollars will be completed and a study of the laser gyro as a rate sensor will be initiated.

Advanced navigation activities are focused on the development of sensors, data filters and guidance system designs which optimize the available science payloads on outer planet missions by increasing aim point accuracy and reducing required trajectory corrections. In FY 1976 and the transition period, the design of algorithms using on-board optical sensors will be initiated. Studies to provide 3 to 6 times more accurate locations of the planets and their satellites will continue. Advanced filtering techniques capable of reducing residual tracking errors by factors of four or more will be sought. Definition of spacecraft maneuver strategies offering up to 30 percent reduction in trajectory correction velocity and associated propellant savings will continue.

Research on autonomous systems for unmanned surface vehicle operation in FY 1976 and the transition period will focus on the evaluation of a robot roving vehicle in a tethered operating environment to test sensors, scene analysis software and control systems now being developed and assembled. Methods for augmenting the vehicles intelligence to permit automatic navigation and path finding will be examined and system improvements added to provide a semiautonomous manuevering capability in a natural environment in subsequent years.

Information Systems Research and Technology

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$5,223	$6,800	$4,780	$5,190	$1,600

OBJECTIVES AND STATUS

The objective of the space information systems research and technology program is to provide advanced components and techniques which permit a greater return of knowledge from space science and application missions by speeding the transmission, processing and reduction of space derived data.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The high resolution sensor effort and robotics and machine intelligence effort and associated funding were transferred from the Information Systems program to the Fundamental Electronics program and the Guidance and Control program, respectively, in FY 1975.

BASIS FOR FY 1976 AND TRANSITION PERIOD ESTIMATES

High capacity, high speeds and extremely flexible data systems will be required to store and process data from future space missions. In FY 1976 and the transition period, unified digital data systems which provide modular organization to permit multimission application will be breadboarded and evaluated to reduce costs and achieve operating lives in excess of six years. A first generation parallel processor with potential image processing rates of 10^{12} bits per second will be completed and evaluation of its application to real time video processing initiated. Evaluation of a 10^{5} bit optical holographic memory breadboard will be completed and tests of new storage materials with potential storage densities of 10^{9} bits per square centimeter initiated.

Microwave technology centers on the design and development of spacecraft radio systems and components for multiple mission applications. In FY 1976 and the transition period, fabrication of a modular microminiaturized dual frequency radio transponder with potential cost savings of 30 percent will continue. Design studies of a millimeter wave radio system to relieve spectrum crowding will be completed and development of appropriate components initiated. A solid state Ku band power amplifier with doubled operating life and 30 percent efficiency will be fabricated and evaluation initiated.

High rate data transfer and tracking activity will focus on the development of laser technology to provide precise position determination for satellite tracking systems and wide bandwidth data links between satellites. During FY 1976 and the transition period, fabrication of a 300 megabit per second carbon dioxide laser transceiver will be completed and evaluation initiated. Development of laser energy sources, detectors, and control and stabilization systems to permit ranging to accuracies of 2 centimeters will continue.

Chemical Propulsion Research and Technology

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$8,108	$7,300	$7,300	$8,290	$2,600

OBJECTIVES AND STATUS

The chemical propulsion program is structured to meet the continuing need for higher propulsion performance, longer system life, lower costs and critical problem solving. To achieve these objectives, the program is focused on the following areas: (a) reusable oxygen-hydrogen systems for reduced transportation system operating costs, (b) long life space storable propulsion for future unmanned planetary exploration, (c) improved low cost solid propulsion for upper stage and orbit insertion applications, and (d) the problem of effects on the atmosphere by rocket exhaust products. These focused efforts are supported by a broadly based research program which explores the fundamental chemical and physical processes common to all chemical propulsion systems.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

In the reusable oxygen-hydrogen systems area, the program will provide the propulsion technology for a reusable Shuttle upper stage, capable of performing at least 20 missions, with minimum refurbishment between flights. During FY 1976 and the transition period, critical engine component technology is scheduled for completion. High performance turbomachinery and thrust chambers capable of 10-hour operational life and 1,200 start/stop cycles will be demonstrated. Investigation of the dynamics and controls of engine systems which incorporate this component technology will commence in FY 1977. Component technology will continue in the areas of fully reusable super insulations, light weight composite feed lines, and high performance oxygen-hydrogen auxiliary propulsion systems.

Future planetary missions require both increased propulsion system capability and in the case of outer planet missions, up to 10 years life. The long life space storable propulsion program is designed to provide the technology of spacecraft propulsion systems that will meet these requirements. The work is directed toward component technology for a fluorine-hydrazine propulsion system. In FY 1976 and the transition period thrust chamber testing will continue for the purpose of developing design criteria for flight weight engine designs. Also in FY 1976, component design criteria for valves and tank materials suitable for 5-year missions will be established. Work will also continue on propellant thermal control systems designed to prevent venting during ground handling, launch operations, in the Shuttle cargo bay, and in deep space.

In low cost solid propulsion, the technology program is directed toward allowing wider use of these inherently low cost systems in NASA missions by developing new capabilities and improving performance of current systems. Specific targets in FY 1976 and the transition period include the following: demonstration that a full scale (weight 3,000 pounds) solid motor can be ignited, quenched, reignited and requenched under simulated vacuum conditions; a controllable dual burn capability that would be useful from Shuttle orbit for

placement of payloads in higher orbits; a thermally sterilized solid motor (exposed six times to 275 degrees Fahrenheit) will be fired to demonstrate that solid motors can be used on or near planets having quarantine restrictions; a high performance kick stage will be tested which will combine a number of advanced technology features allowing nonpropellant weight to decrease to only 5 percent of the total motor weight. This type of motor is necessary to perform some of the difficult planetary missions in the 1980's.

Solid fuel boosters release exhaust products into the atmosphere during launch. A number of NASA centers are working under a program funded by the Office of Manned Space Flight and the Office of Aeronautics and Space Technology to determine the types and roles of interactions between the exhaust products and the complex species natural to the atmosphere. In FY 1976 and the transition period, the effort funded by the Office of Aeronautics and Space Technology will concentrate on understanding effects in the stratosphere. Some experiments will be performed with new types of propellants which minimize pollutants in the exhaust.

Basic research will be continued to deepen the understanding of the chemical and physical processes that occur in rocket propulsion systems and to establish new techniques of energy storage and use. Work in these areas in FY 1976 and the transition period will include studies of combustion and expansion losses to improve efficiency; evaluations of the influence of baffles and cavities on combustion stability; determination of the properties of liquid propellants at very high pressures; solid propellant polymers and viscoelastic properties; combustion and fire extinguishment in zero gravity; stabilization of activated states of elements with specific impulse potential of over 1,000 seconds; and a continuing evaluation of propulsion systems based on laser beam energy transmission.

Electric Propulsion Research and Technology

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$5,172	$4,900	$4,400	$4,200	$1,200

OBJECTIVES AND STATUS

The objective of this program is to provide the research and technology for high specific impulse (greater than 1,000 seconds) electric propulsion systems needed for advanced capabilities in near-earth and planetary/interplanetary applications. Specific areas of investigation include: (1) auxiliary electric propulsion technology for station keeping and attitude

control of long life application type satellites, (2) primary solar electric propulsion technology for use with the Shuttle and Tug to augment their performance capability for accomplishing high energy missions in the 1980's and 1990's and, (3) basic research in fundamental processes involved in electric propulsion to extend reliability and life, and to explore the full potential of electric propulsion.

CHANGES FROM FY 1975 BUDGET ESTIMATE

A one-half million dollar reduction was taken in the Electric Propulsion program as one of the actions necessary to formulate the FY 1975 Operating Plan. A recent re-examination of the near-term mission requirements for electric propulsion justify this decision to slow the activity in the Electric Propulsion program at this time.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

In the area of auxiliary electric propulsion, evaluation of the small one millipound, 150 watt, cesium ion thruster flight experiment aboard the Application Technology Satellite (ATS-6) will be continued during FY 1976 and the transition period. In addition, ground test programs presently underway to demonstrate 5-year cycle life capability for ion thruster systems will be continued. Evaluation of resistojets using low freezing point monopropellants to simplify the onboard satellite thermal control system will also be continued in FY 1976 and the transition period.

In the area of primary solar electric propulsion, the program is aimed at demonstrating the technology for a 3,000 second specific impulse, modular, mercury ion thruster system, and the technology for large, lightweight solar arrays, applicable to a wide range of missions. During FY 1976 and the transition period, endurance testing of 30-centimeter engineering model ion thrusters (2.75 kilowatt) will be continued including testing of a thruster with a breadboard model power processor. In addition, work on large (12.5 kilowatts per wing) lightweight (15 kilogram/kilowatt) solar arrays, aimed at demonstrating structural and dynamic suitability for solar electric propulsion mission applications will be continued in FY 1976 and the transition period.

In the area of basic research, ion thruster research aimed at evaluating the use of other propellants and at understanding the ion discharge chamber process such as its relation to ion surface erosion will continue in FY 1976 and the transition period.

Space Energy Systems Research and Technology

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$7,882	$8,200	$8,100	$7,290	$2,200

OBJECTIVES AND STATUS

The objective of the Energy Systems Research and Technology program is to make available low cost, long-lived, reliable, high power density and high-energy density components and energy systems for spacecraft.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The funding change reflects a reduction in the endurance testing of an alternate Auxiliary Power Unit (APU) for the Shuttle to the minimum needed to gain reasonable confidence in the unit.

BASIS FOR FY 1976 AND TRANSITION PERIOD ESTIMATES

In the area of solar cells and arrays, emphasis is on high efficiency, radiation resistant cells; and on lightweight, high power density, modular arrays. Thin (4 to 5 mil) cells will be assembled into modules and evaluated in simulated space tests in FY 1976. Research will continue in FY 1976 and the transition period on loss mechanisms and their elimination, to improve both efficiency and radiation resistance of solar cells. Details of a versatile array module will be developed. Solar cell standards will be prepared for balloon flights (above the atmosphere) and distributed to the users.

For energy storage, the rechargeable Nickel-Cadmium (Ni-Cd) cell and battery is being improved in uniformity, reliability and life. The non-destructive, accelerated test program will be continued in FY 1976 and the transition period with the objectives of (1) devising a simple, quick test method for use by spacecraft engineers; and (2) predicting, with a high degree of confidence the performance of cells and batteries for space missions, particularly in low orbit. Work on Silver-Zinc (Ag-Zn) cells with inorganic separators will continue, to obtain 5-year devices for synchronous orbit, with up to 3 times the energy density of NiCd. In addition, the research for low temperature solid electrolytes will be continued, to attain a tenfold increase in energy density and an indefinite life.

In the thermomechanical systems area, testing of available components of a highly efficient (20-25 percent) 0.5-2.0 kilowatt electric gas turbine

system for use with isotope heat sources is continuing. In FY 1976 performance testing will be conducted on an experimental turbocompressor-alternator unit currently under construction. Upon completion of these tests, the turboalternator and other key components will be delivered to the Energy Research and Development Administration (ERDA) for a breadboard system test which will demonstrate the systems performance capability and technical readiness.

The power processing program will be continued in FY 1976 and the transition period with emphasis on high power, long life and lower cost components. Of particular interest will be the continuation of a program aimed at mathematically modeling a power processing system. Such a capability will permit the design and optimization of systems on paper and greatly facilitate the design of standarized, low cost systems.

Nuclear Energy Research and Technology

	1975			
	Budget	Current		Transition
1974	Estimate	Estimate	1976	Period
	(Thousands of Dollars)			
$2,792	$2,200	$2,200	$2,200	$700

OBJECTIVES AND STATUS

Research and technology investigations will be conducted in areas related to advanced applications of nuclear energy in space. Building upon the extensive space nuclear programs of the past decade, these activities will maintain a viable, long-range capability in nuclear research for space power and propulsion while providing important benefits to the Nation in its concerns for future energy sources.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Research is being conducted in the field of thermionic energy conversion with a long-range goal of achieving efficiencies up to 30 percent with operating temperatures as low as 1,100 degrees Centigrade. Converter performance of this character would make thermionic converters extremely useful for topping cycles in both nuclear and fossil-fueled power plants. They would also be the logical choice for nuclear electric propulsion systems for a ferry vehicle for orbital transfer of spacecraft from and to the Space Shuttle or for future outer planet missions. The present ongoing research program will continue in FY 1976 and the transition period. The program includes fundamental investigations of the physics of emitter and collector materials and the inter-electrode plasma which are the critical areas in achieving high efficiency converter performance. In addition to analyses

51-423 O - 75 - 23

and testing of new converter designs, preliminary systems studies will continue to be conducted of their applications in topping cycles and nuclear or solar powered electrical generating systems.

During FY 1976 and the transition period, gas-core reactor research will continue to investigate the production of fission energy with the nuclear fuel in the gaseous or plasma state. Gas-core reactors may become important new sources of energy since they are efficient users of uranium fuels, may be effective breeder reactors, have inherent safety features, and may permit the efficient transformation of fission energy to other forms by thermo-or photo-chemical means. Low power, low temperature, self-critical experiments employing gaseous uranium hexafluoride began in FY 1975 under NASA funding at the Los Alamos Scientific Laboratory. In FY 1976 a criticality experiment at up to one kilowatt power will be conducted. In addition, spectroscopy of electrically heated uranium plasmas and of uranium plasmas produced by compression of uranium hexafluoride in a ballistic piston compressor and by fissions that are induced by external neutron sources, will be conducted in the FY 1976-1977 period.

High Power Lasers and Energetics Research and Technology

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$4,600	$5,000	$5,000	$5,410	$1,600

OBJECTIVES AND STATUS

The high power laser and energetics program provides, through basic research and experimental engineering, major advances in power generation, conversion, and transmission which will be the basis for future capabilities in space and which will apply to the long-range energy need on earth.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Research is conducted in the area of plasmadynamic energy systems to establish the knowledge required to produce, confine and utilize plasmas for advanced power and propulsion systems of potential importance to space missions. A project to investigate combustion-driven Magnetohydrodynamic (MHD) generators for very high power densities is in progress. In this project, combustor experiments will be completed during the period FY 1975 and 1976. Along with this work, superconductive magnets will be developed and tested for application to the generator, including a cooperative effort with the Air Force to assist the Air Force Aeronautical Research Laboratory in applying the NASA superconductive magnet expertise to their needs. This

will be followed by generator tests in subsequent years. Operation of the large superconducting magnetic mirror apparatus and the bumpy torus device will continue in FY 1976 and the transition period to explore the physics of direct current plasma heating and other fundamental problems which are of major significance to fusion energy for terrestrial and space applications. During FY 1974-1975, plasma temperatures at 50 million degrees Kelvin were achieved in the superconducting mirror apparatus, using helium. In FY 1976 and the transition period, even higher temperatures may be obtained, as a result of a current upgrading of the device.

In magnetics and cryophysics, research is conducted to achieve stable, intense magnetic fields from magnets of minimum mass and power use, and to understand the physics of materials and devices exposes to low temperatures and intense fields. In FY 1975, tests demonstrated the capabilities of a twisted filament superconductor in a small magnet. In the future, long lengths of this conductor will be procured from a production line process and tested in large magnet coils. Cooling will be demonstrated with a small magnetic heat pump during FY 1976 and the transition period.

Basic research is conducted to provide fundamental data and to investigate novel concepts in the emission and absorption of radiation from all states of matter in support of a broad range of possible applications in power generation, propulsion, lasers, space environment, and atmospheric physics. During FY 1975, the nuclear pumping of a xenon-helium laser was achieved, that is, the direct conversion of fission fragment energy into coherent light. In FY 1976 and the transition period, this method will be employed for energizing by nuclear power a high pressure xenon laser, that could radiate at larger power and higher frequency.

An integrated program of laser systems research and technology is being conducted to determine whether high power lasers can make a major impact on aerospace mission capabilities. To make this evaluation, a continuously operating laser will come into operation in FY 1975-1976 to determine what technical barriers may exist to long duration operation at high powers and how to obtain high efficiency. The areas of laser optics, beam transmission both in space and from earth-to-space with adaptive mirror systems, and conversion of laser energy to electrical energy or directly to propulsive forces will be studied during FY 1976 and the transition period as they apply to potential space applications. In this context, use is being made of the major laser programs in other agencies.

Entry Research and Technology

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$7,605	$5,878	$5,720	$5,700	$1,700

OBJECTIVES AND STATUS

The entry research and technology program provides the technology base required to improve entry spacecraft design, operation, safety, and reliability.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The funding change reflects a reduction in the number of wind tunnel hours required to support the current Shuttle configuration.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

This effort supports the Shuttle program by providing wind tunnel testing and expertise for aerothermodynamic analysis and special problem solving. During FY 1976 and the transition period, investigations will be carried out to increase the usable center of gravity range, determine heat transfer effects between orbiter and external tank, determine separation aerodynamics, and plume effects on launch configuration aerodynamics. Computer codes which include the correct air chemistry parameters will be developed to compute windward surface flow over the Shuttle.

The program also defines the aerothermodynamic environment for planetary atmospheric entry probes through the use of simulation facilities and theoretical predictive techniques. In FY 1976 and the transition period attention will be focused on the high velocities of outer planet entry with emphasis on determining the critical high temperature radiative property data and the effects of heat shield ablation products on the shock layer flow around planetary entry probes.

Research will also be pursued to acquire aerothermodynamic technology for the design of advanced earth orbital vehicles for the 1990 time period. Calculation techniques will be developed during FY 1976 and the transition period to predict with a high degree of accuracy the complete three-dimensional flow fields about vehicles, including heating and real gas effects.

System Studies Program

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$1,300	$1,600	$1,600	$1,600	$400

OBJECTIVES AND STATUS

The overall program objective is to identify and evaluate the technology requirements of advanced space systems and to assess the effects of technology advances on space program alternatives.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

The effort to determine long-term program enabling technology needs will continue to receive major emphasis during FY 1976 and the transition period. In order to provide more comprehensive research and technology planning recommendations, the studies will be broadened to include Earth and Ocean Physics programs, Physics and Astronomy programs and Lunar programs. The long-term investigations of advanced Planetary, Earth Observations and Transportation Systems will continue examining system alternatives and their impact on technology needs. It is intended to pursue further technology oriented studies such as the communications and the environment control tasks. Instrument development and detector research will be studied with the goal of acquiring or generating comprehensive forecasts of both technology development trends and total (scientific and applications) program needs. Study efforts will give increased attention to projected software requirements.

In FY 1976 and the transition period, future mission, concept feasibility studies will continue as a basis for providing technology focus. Interstellar Communications, Single-Stage-to-Orbit, Advanced Planetary Spacecraft, and Titan (Saturn Moon) Exploration studies are in progress. Advanced concepts such as those which may derive from the "Outlook for Space" results will be considered for study.

Technology readiness studies will continue in FY 1976 and the transition period for selected candidate new programs. The study of candidate Mariner change recommendations for the Saturn Orbiter mission will be completed, as will the evaluation of technology alternatives for the recoverable NASA Space Tug.

The evaluation of Research and Technology Base programs, including measures of benefit and risk in the achievement of targets and objectives, will continue during FY 1976 and the transition period. Methodology will be developed with initial emphasis on new initiatives.

Systems Technology Programs

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Materials and structures systems technology....	---	---	---	$500	$300
Guidance, control and information systems technology.....	---	$800	$800	700	300
Entry systems technology	$1,050	1,000	1,000	1,000	200
Energy and environmental systems technology....	835	465	465	---	---
Total.....	$1,885	$2,265	$2,265	$2,200	$800

CHANGES FROM FY 1975 BUDGET ESTIMATE

The Energy and Environmental Systems Technology program, shown under the Systems Technology Programs category in the current budget, reflects only a small remnant of the program described in previous budgets. Responsibility for the major portion of the Energy and Environmental Systems Technology program was transferred from the Office of Aeronautics and Space Technology to the new Office of Energy Programs, and is addressed in the Energy Technology Applications program of the current budget.

Materials and Structures Systems Technology

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
---	---	---	$500	$300

OBJECTIVES AND STATUS

This activity is directed to accelerating the transfer of advanced materials and structures technologies to application in the design of space vehicle systems. Critical system applications are selected and components are designed, fabricated and tested in the laboratory to demonstrate the validity of the predicted improvements. If necessary and appropriate, space flight testing will also be performed.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Future space transportation systems will benefit strongly if the temperature limits for composite structures can be increased above the limits of 350 degrees Fahrenheit. In FY 1976, the Composites for Advanced Transportation Systems program will be initiated to develop a practical polyimide resin composite system with the capability for operating at 600 degrees Fahrenheit. The initial activity will focus on materials and manufacturing processes and on design methods development. This will be followed by design and fabrication of structural components for laboratory testing. It is projected that evaluation of laboratory tested components will be completed by the end of FY 1979.

Guidance, Control and Information Systems Technology

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
---	$800	$800	$700	$300

OBJECTIVES AND STATUS

The purpose of this systems technology program is to demonstrate the capabilities of advanced electronic devices and system concepts to provide improved performance, increased reliability and/or reductions in cost of spacecraft guidance, control and information systems.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

The Solid State Data Storage System, a program to provide a no-moving-part data storage system for aerospace vehicles with 10^8 bits of storage capability and reliability of 2×10^4 hours, or twice that of the average spaceborne tape recorder, was initiated in FY 1975. This Solid State Data Storage System uses magnetic "bubble" domain technology as the storage media, offers exceptional flexibility in data formats and can be sized to a variety of data storage applications through its modular organization. Memory elements and system architectural designs are being developed in FY 1975. In FY 1976, design, fabrication and evaluation of an engineering model data storage system will be initiated. In subsequent years, a flight model will be constructed, tested and qualified to space flight standards to demonstrate feasibility of a solid data storage system by the end of FY 1978.

Entry Systems Technology

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$1,050	$1,000	$1,000	$1,000	$200

OBJECTIVES AND STATUS

The objective of the program is to perform and evaluate manned and unmanned experiments in flight that demonstrate or validate ground based entry research and technology to improve spacecraft design, operation, and reliability; to carry out studies to investigate spacecraft system feasibility and to provide direction and timely execution of supporting ground-based research and technology.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

The Atmospheric Flight Experiments program, a joint Air Force/NASA research project, will carry out piloted flight experiments to evaluate flight characteristics, aerodynamic performance, and handling qualities of the X-24B aircraft at speeds from low supersonic through landing. The project utilizes the X-24B aircraft, which has a hypersonic lift-to-drag ratio of approximately 2.5 and is characteristic of the double delta class of wingless aircraft with potential use for future spacecraft or hypersonic military aircraft. In FY 1976 and the transition period, studies will continue to define the stability and control, vehicle handling, and piloting problems of the X-24B. Studies of flow separation, boundary layer noise, and vibration will be continued. The program will be completed during the transition period. The experience gained in this program has and will have contributed to the Shuttle design and flight operations as well as technical and flight data information for future hypersonic vehicles.

Experimental Programs

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Space technology shuttle payloads.....	---	$2,000	$2,000	$3,700	$1,110
Total.....	---	$2,000	$2,000	$3,700	$1,110

OBJECTIVES AND STATUS

The Space Technology Shuttle Payloads program will define and develop space facilities which enable researchers to utilize in an economical manner the capabilities provided by the Shuttle and Spacelab systems. These facilities will extend the capabilities of the ground-based research facilities, permitting research and technology investigations to be conducted in space where the unique attributes of vacuum, weightlessness, radiation, and/or location are essential. Experiments in specific discipline areas and which require shuttle capabilities are supported to establish the feasibility of the effort and to determine the technical and programmatic resources required for a subsequent flight program.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

The Advanced Technology Laboratory (ATL), which utilizes the Spacelab to support technology experiments that require man interaction in space, is being supported in FY 1975, 1976 and the transition period. This effort includes participation in Shuttle and Spacelab reviews to insure compatibility with the ATL requirements, refinement of potential experiment requirements, and a systems and requirements definition study. A space technology/shuttle experiment summer workshop will be conducted during CY 1975 to define the technology required for CY 1980 to 1990 missions. Feasibility and definition studies of Shuttle compatible experiments to satisfy these technology requirements identified by the summer workshop will be conducted during FY 1976 and the transition period. Additional FY 1976 and transition period feasibility and definition efforts are focused on basic physics and chemistry experiments, an entry technology payload, and a Shuttle contamination experiment.

The Long Duration Exposure Facility (LDEF) is a low cost, free-flying, completely passive, reusable payload which will expose large numbers of experiments to the space environment. LDEF is proposed for deployment on an early Shuttle flight, with later retrieval, to obtain early data which will be beneficial to other Shuttle payloads. It is also being proposed for use during the shuttle development program as a method of verifying the Shuttle cargo bay environments, for demonstrating the space operation of the remote manipulator system, and for developing payload handling fixtures and procedures at the launch site. The FY 1976 and transition period effort is focused on the completion of the design package, initiation of procurement and fabrication activities, and on the development and expansion of a user (experiment) community.

Experiments which have been adequately defined as to technical scope and resource requirements are being supported for hardware development in preparation for an early Spacelab mission. The research module in which basic fluid physics and drop dynamics experiments will be conducted is one such effort. During FY 1976 the design packages for these experiments will be completed.

Low Cost Systems Program

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Low cost systems program	$3,100	$5,000	$5,000	$6,100	$1,500

OBJECTIVES AND STATUS

The objectives of the Low Cost Systems Program are to prescribe approaches to reducing the overall costs of space systems by the standardization of components and systems and improvement of business and programmatic practices.

Standard Space Equipment Development

Use of standardized capabilities will reduce the costs of designing and developing unique equipment for different missions. Cost per unit will decline with quantity production; reliability and assurance will improve; delivery schedules will be shortened.

For certain utility functions which are common to many space systems, this program identifies space equipment and component requirements, defines their interfaces, and developes suitable standard subsystems, components, and/or software for use by the projects.

Standard equipment and components will be produced for spacecraft in five areas. These are: Power; Auxiliary Propulsion; Stablization, Guidance and Control; Communications and Data Handling; and Ground Support Equipment.

The availability of the equipment and/or software is made known agency-wide through a catalog.

Power

The objective is to reduce the cost of electrical power subsystems for NASA spacecraft by developing and qualifying an array of standard equipment designs, covering a range of needed capabilities.

In the FY 1976 and the transition period development of solar arrays, batteries, and transformers will be continued.

Auxiliary Propulsion

The selection, development and qualification of low cost standardized auxiliary propulsion components are the objectives. Options will be developed for tank and thruster sizes.

In FY 1976 and the transition period development of standard hydrazine attitude control propulsion elements and attitude control thrusters will be continued.

Stabilization, Guidance and Control

The objectives here are to identify, develop and qualify stabilization, guidance and control equipment and software that has utility for various space flight programs.

In the FY 1976 and the transition period development of standard fine solar sensor stabilization units, panoramic attitude sensors, and single axis inertial reference units will be continued.

Communications and Data Handling

The objectives are to coordinate mission requirements, and develop and qualify standardized flight equipment for spacecraft communications and data management.

In FY 1976 and the transition period development of spacecraft transponders, magnetic tape recorders, flight computers, telemetry modulator components and digital data interface units will be continued.

Ground Support Equipment (GSE)

The objective here is to reduce the cost of GSE by standardizing on existing GSE where practical to effect cost savings and developing standardized GSE where it is proven to be cost effective.

In FY 1976 and the transition period the following candidates for standardization will be examined: test equipment, transportation and handling equipment, servicing equipment, and launch control and monitoring equipment.

Business and Program Practice Studies

The objective of the business and program practice efforts is to identify opportunities for effecting cost savings within current and future projects.

Program Practices

In FY 1976 and the transition period the following areas will be explored: development and maintenance of a developed component inventory, new lower cost methods of testing, reliability and quality assurance, spares philosophy, spacecraft integration, documentation and experiment development practices.

Business Practices

In FY 1976 and the transition period the Business Practices activity will continue to review and evaluate NASA's present space business practices with emphasis on the acquisition process, contract execution, and business data processing.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

BUDGET SUMMARY

OFFICE OF ENERGY PROGRAMS — ENERGY TECHNOLOGY APPLICATIONS

SUMMARY OF RESOURCES REQUIREMENTS

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Energy research and technology	$2,693	$2,085	$2,035	$2,200	$550
Energy applications	2,000	2,000	2,000	3,000	750
Systems analysis	---	350	400	700	200
Total	$4,693	$4,435	$4,435	$5,900	$1,500
Distribution of Program Amount by Installation					
Johnson Space Center	$430	$380	$380	$1,875	$375
Kennedy Space Center	---	---	---	50	25
Marshall Space Flight Center	875	550	550	250	50
Goddard Space Flight Center	---	230	230	225	75
Jet Propulsion Laboratory	2,008	2,500	2,500	2,500	675
Ames Research Center	---	225	225	175	75
Flight Research Center	28	---	---	---	---
Langley Research Center	316	90	90	75	25
Lewis Research Center	1,036	460	460	750	200
Total	$4,693	$4,435	$4,435	$5,900	$1,500

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

OFFICE OF ENERGY PROGRAMS — ENERGY TECHNOLOGY APPLICATIONS

PROGRAM OBJECTIVES AND JUSTIFICATION

The broad goal of the National Aeronautics and Space Administration energy programs is to assist in insuring the attainment and maintenance of national energy self-sufficiency. In order to accomplish this goal, the Office of Energy Programs has four major objectives as follows:

1. Provide support in advanced research, technology and development to other Federal agencies.

2. Define and, if appropriate, implement programs in program areas related to energy which require the broad application of aerospace systems technology and management techniques.

3. Provide support to Federal, state and local governmental agencies in the application of aerospace technology.

4. Evaluate the potential of various elements of aerospace technology in a comprehensive energy matrix through the application of the techniques of systems analysis and analytical modeling.

The FY 1976 activities of the Office of Energy Programs consist of small research and technology projects designed to identify, as well as mature, technologies of importance to the national energy community. These activities will be concerned with applying aeronautics and space technology to the discovery, production, conversion, transmission, storage, conservation, utilization and management of energy in terrestrial applications. They will include exploration of new and favorable alternatives to ongoing NASA research and technology. These activities will be conducted in the areas of energy research and technology, energy applications and systems analysis.

BASIS OF FUND REQUIREMENTS

Energy Research and Technology

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
$2,693	$2,085	$2,035	$2,200	$550

OBJECTIVES AND STATUS

The Energy Research and Technology is aimed at effective utilization of the existing NASA capabilities and experience in relation to the national energy research and development program being pursued by the agencies having primary energy program responsibilities.

A part of the effort to relate experience to problems is accomplished by the direct NASA participation in the continuing energy research and development planning activity. The balance of this effort must be accomplished by direct support of both in-house and contractual efforts to refine, translate and adapt the wide range of aeronautics and space technologies to the appropriate energy program activities.

The process that is being developed to assure that the technological strength of NASA is brought to bear in support of the energy programs involves two discrete, but related, elements; technology identification and verification, and critical technology advancement. Technology identification and verification involves a continued search for technology existing in aeronautics and space disciplines which could solve energy problems as well as experimental verification of known aerospace technology to terrestrial energy problems. Critical technology advancement includes the definition of assumptions regarding technology levels which can be achieved in systems proposed for solving energy problems, as well as understanding the technology advancements required to achieve predicted levels of performance within specified time periods.

In addition to using this general process to assure that competent NASA recommendations are made to ERDA and the other organizations directly authorized to fulfill the energy research and development program responsibilities, it is also being used to define comprehensive technology programs in specific areas directly related to the most relevant NASA experience and capabilities.

CHANGES FROM FY 1975 BUDGET ESTIMATES

With the creation of the Office of Energy Programs energy-related activities previously in NASA's Aeronautics and Space Technology program were assigned to the Energy Research and Technology program. As a result the distribution of resources between tasks was altered to take into account two major factors: the needs of the new office to better define energy-related research and technology areas that would make appropriate use of aerospace technology, and the expanded level of support provided to other agencies on a reimbursable basis. More specifically, small efforts that NASA has funded earlier are now being continued on a reimbursable basis in support of programs of other agencies. These efforts include: Potassium ranking topping cycle, Energy conversion alternatives study, Energy storage systems, Automotive gas turbine, and Aerodynamic drag of large road vehicles.

NASA resources which would have supported small efforts in these areas now support high efficency, low pollution internal combustion engines (including hydrogen injection for automobiles) and energy systems research and technology support projects.

An additional modification was made in the FY 1975 projects by transferring project responsibility for Remote Sensing of Smokestack Pollution and Air Pollution Source Identification to the Office of Applications.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

The funding for Energy Research and Technology supports identification and verification in areas that will include materials for high temperature energy conversion systems and thermal, mechanical and electro-chemical energy storage techniques; the analysis of critical technological aspects of systems design concepts and technical proposals and approaches to energy problems utilizing aerospace related technology; and completion of selected program definition efforts initiated during FY 1975 in the following technology areas: multipurpose gas turbine, terrestrial (commercial) fuel cells, advanced surface propulsion and hydrogen energy technology.

The hydrogen injection concept to achieve a higher efficiency, low pollution, internal combustion engine has been successfully demonstrated in an engine test stand. The next phase planned will be a demonstration of the engine and the "on board" hydrogen generator in an automobile. To support this, a vehicle demonstration plan is being prepared for consideration by ERDA.

Energy Applications

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
$2,000	$2,000	$2,000	$3,000	$750

OBJECTIVES AND STATUS

There are many foreseeable advancements in our methods of producing and conserving energy which can benefit from the integrated application of aeronautics and space technology. Within the Energy Applications program, investigations of potential advancements will be conducted including a study of the technical and economic feasibility of satellite solar power and satellite power relay systems, studies and research of systems and subsystems which are part of integrated utility systems, and studies of the focused application of remote sensing and rapid data handling techniques to energy resource assessment and environmental effects.

CHANGES FROM FY 1975 BUDGET ESTIMATE

With the creation of the Office of Energy Programs, a review of the program direction, emphasis, planning and utilization of resources for energy-related activities previously under the cognizance of the Office of Applications was conducted. As a result of this review, further support of the Earth-based Solar Power Conversion and Delivery System Study was deferred pending the results of the FY 1974 funded effort and the establishment of the nature of possible funding support from other interested agencies. Further support of the Survey of Hydrogen Production Methods was deferred pending the results of a new program definition effort in hydrogen energy systems technology. Similarly, further support of the Space-based Solar Power Conversion and Power Relay Systems Study was reduced until the completion of an integrated Satellite Power System Program. These adjustments allowed a refocusing to put additional effort in areas of technology identification and verification and system analysis.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Funding for the Satellite Power Systems program will be used to investigate the economic, environmental, and operational aspects of the space-based collection, conversion, and relay of solar energy concepts and continue to pursue technological areas pertinent to such concepts. Program definition studies will be undertaken to identify and prioritize the critical technologies that presently constrain the technological, operational, and economic assessment of satellite power concepts, to identify ongoing research and technology within NASA related to satellite power concepts, and to structure an orderly program leading to feasibility decisions regarding the concepts.

Support of the Utility Systems Technology program will apply aerospace-derived technology, systems integration engineering, and management techniques to the analysis and design of community services of power, water, liquid and solid waste management. The program is oriented toward short term (pre-1985) energy and environmental conservation via integrated utility systems for residences and small communities. This program, conducted partly in cooperation with the Department of Housing and Urban Development at the Johnson Space Center modular integrated utility system (MIUS) integration and subsystem test (MIST) facility, will be dedicated to the development, integration and testing of waste water and solid treatment concepts, production of electrical and thermal energy from these waste products, low cost heating and cooling, energy storage devices, humidity control, and water quality monitoring.

Technology developed as a part of the space program offers a potential means for efficiently expediting the assessment of the nation's energy resources. Funding will be focused on the applicability of rapid turn-around data handling as a means of increasing the efficiency of oil and gas exploration in frontier areas, such as the outer continental shelf. Remote sensing

51-423 O - 75 - 24

technology appears to require further development in most cases before becoming a large scale operational approach. However, in those areas where the technology appears to be sufficiently mature, chiefly in the area of hydroelectric power, studies will be instituted to determine the impact of a systems approach, including remote sensing, on the problem of managing the Nation's energy supply. As the technology of remote sensing continues to mature, we anticipate its application to a broader range of problems dealing with the national energy supply.

Systems Analysis

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)			
---	$350	$400	$700	$200

OBJECTIVES AND STATUS

Systems studies and analysis covers the systematic identification and maintenance of existing energy project data bases in order to support the broad analyses involving clearly defined boundaries with respect to technical, economic, environmental, political and social assumptions.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The Office of Energy Programs was established late in FY 1974 to better coordinate a variety of NASA-managed activities funded by this and other agencies. As a consequence of this reorganization, a number of previously identified energy-related projects that were to be accomplished or continued in FY 1975 were consolidated into more broadly applicable program areas. Many were funded by other agencies, which permitted the application of NASA resources to specific Systems Analysis efforts which are designed to identify and maintain the most appropriate NASA energy project data bases.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

In FY 1976, funding will be utilized to continue to build a data base of existing energy project information, to develop the capability to evaluate the interaction of individual energy systems with the total environment in which each system must develop and operate, and to continue the aim to make this information available prior to implementation of individual projects set forth in other portions of the energy program.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

BUDGET SUMMARY

OFFICE OF TRACKING AND DATA ACQUISITION — TRACKING AND DATA ACQUISITION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(In Thousands of Dollars)			
Operations	$191,900	$192,800	$192,900	$192,400	$51,200
Systems implementation	42,900	48,000	42,300	41,400	12,900
Advanced systems	9,200	9,200	9,200	9,200	2,300
Tracking and data relay satellite system	---	---	3,600	---	---
Total	$244,000	$250,000	$248,000	$243,000	$66,400
Distrubution of Program Amounts by Installation:					
Goddard Space Flight Center	$175,113	$180,900	$176,200	$169,100	$45,300
Wallops Flight Center	5,544	6,900	6,200	5,100	1,400
Jet Propulsion Laboratory	46,833	45,500	48,400	51,500	15,300
Flight Research Center	1,978	1,800	2,600	2,400	600
Langley Research Center	200	---	---	---	---
Headquarters	14,332	14,900	14,600	14,900	3,800
Total	$244,000	$250,000	$248,000	$243,000	$66,400

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

OFFICE OF TRACKING AND DATA ACQUISITION

TRACKING AND DATA ACQUISITION 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, and other countries and international organizations engaged in space research endeavors.

Support is provided for manned and unmanned flights; for spacecraft, sounding rockets, and research aircraft; for earth orbital and suborbital missions; for lunar and planetary missions; and for space probes.

Types of support provided include: (a) tracking to determine the position and trajectory of vehicles in space; (b) acquisition of scientific data from onboard experiments; (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 astronauts and acquisition of biomedical data on their physical condition; (f) communication of information between the various ground facilities and central control centers; and (g) processing of data acquired from the launch vehicles and spacecraft. Such support is essential for achieving the scientific objectives of all flight missions, for executing the critical decisions which must be made to assure the success of these flight missions, and, in the case of manned missions, to insure the safety of the astronauts.

Tracking and data acquisition support is provided by a world-wide network of NASA ground stations and an instrumentation ship, supplemented by appropriate instrumented aircraft. These facilities are interconnected by a network of ground communications lines, undersea cables, and communication satellite circuits which are leased from domestic and foreign carriers and which provide the capability for instantaneous transmission of data and critical commands between spacecraft and the control centers in the United States from which the flights are directed. 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 systems to support continuing, new, and changing flight project requirements; and (c) the investigation of advanced tracking and data acquisition techniques and the development of advanced tracking and data acquisition instrumentation.

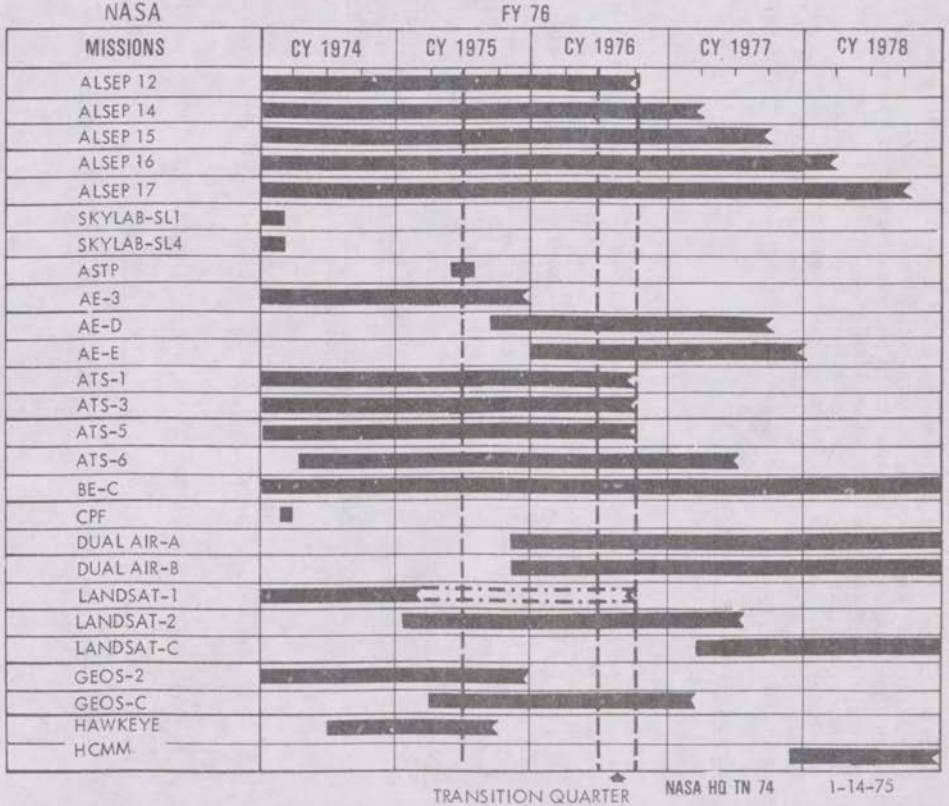
BASIS OF FUND REQUIREMENTS

Operations

The FY 1976 request reflects a leveling off in funding requirements for network operations. Savings associated with the closing of stations are being offset by significant cost escalation in all program areas and, in particular, in the overseas operations area. In both the Spaceflight Tracking and Data Network and the Deep Space Network the support workload will remain relatively high with the Apollo Soyuz Test Project and Viking being the two new major increments in tracking and data acquisition support during FY 1976.

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(In Thousands of Dollars)			
Spaceflight tracking and data network.....	$ 99,525	$ 98,200	$ 98,500	$ 97,000	$26,000
Deep space network.	32,975	34,600	35,500	38,400	10,200
Aeronautics and sounding rocket support.....	4,300	5,500	5,200	4,100	1,100
Communciations.....	32,500	30,900	29,900	27,900	7,000
Data processing....	22,600	23,600	23,800	25,000	6,900
Total.....	$191,900	$192,800	$192,900	$192,400	$51,200

SPACEFLIGHT TRACKING AND DATA NETWORK WORKLOAD



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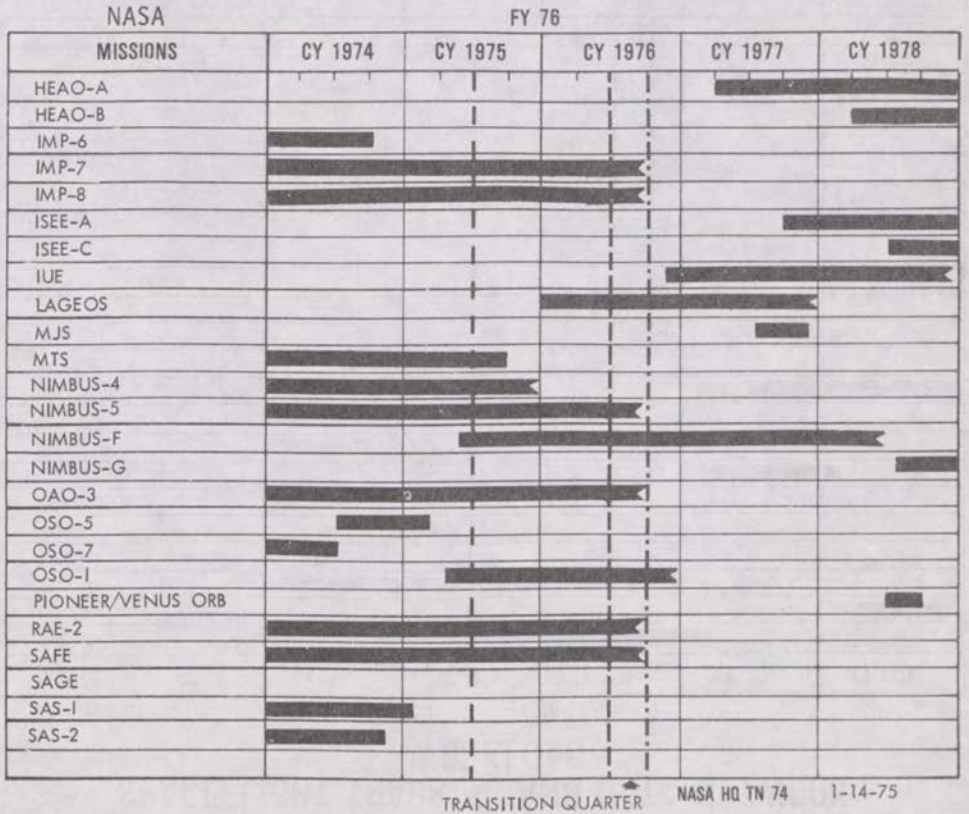
SPACEFLIGHT TRACKING AND DATA NETWORK WORKLOAD



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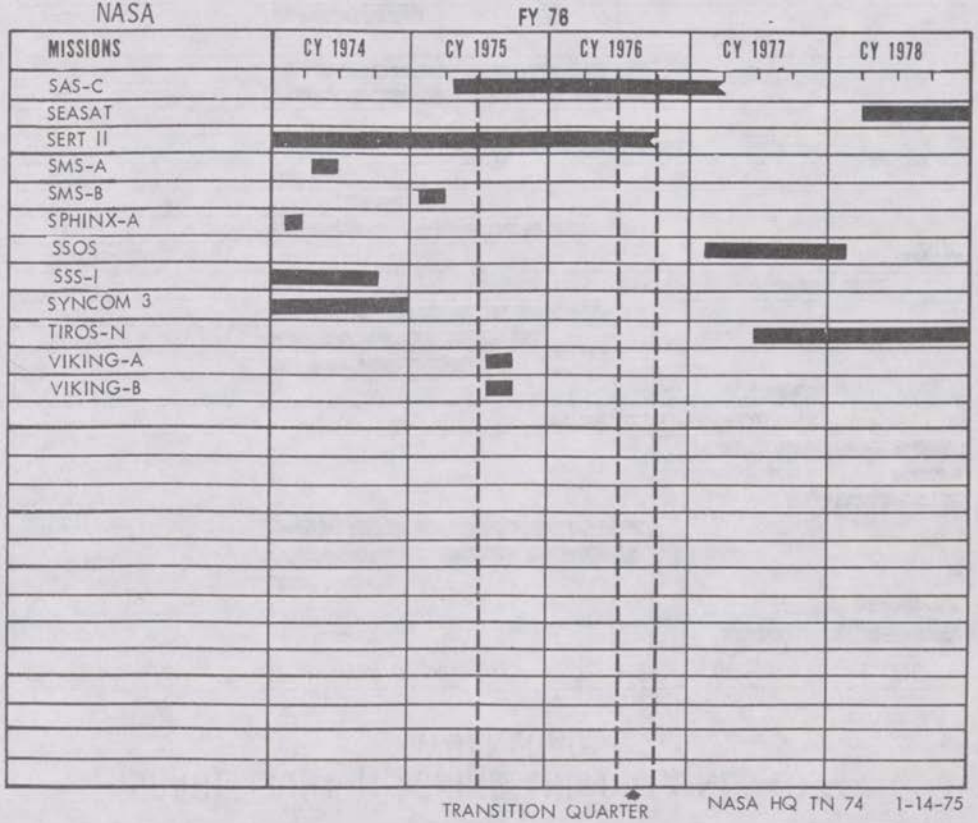
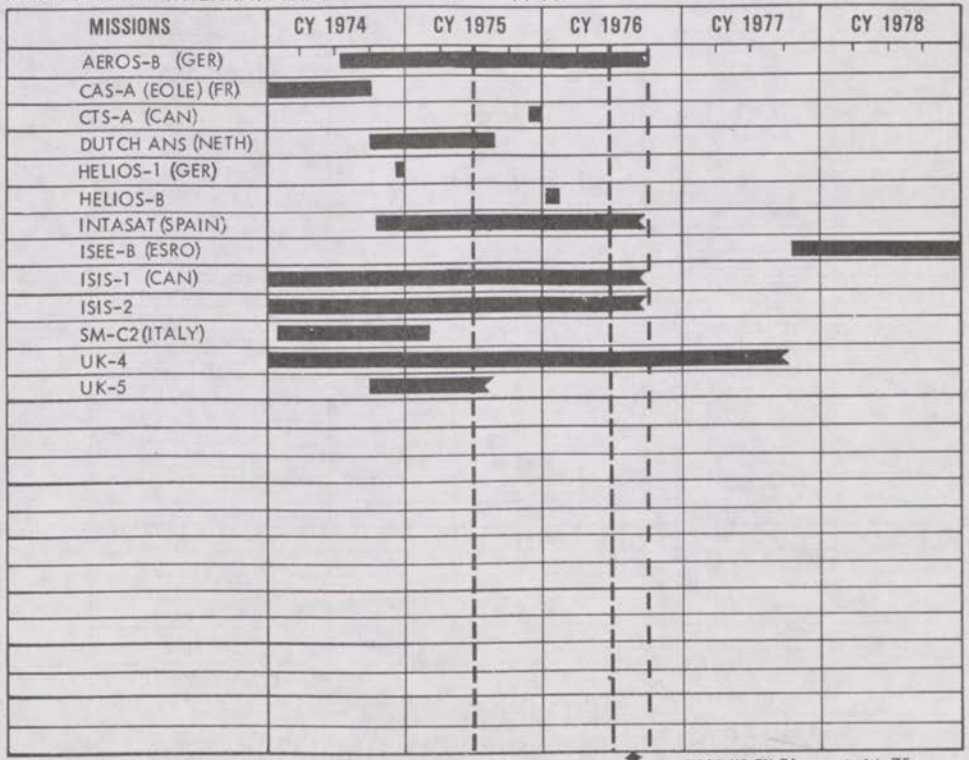


RD 11-6

SPACEFLIGHT TRACKING AND DATA NETWORK WORKLOAD

COOPERATIVE INTERNATIONAL

FY 76



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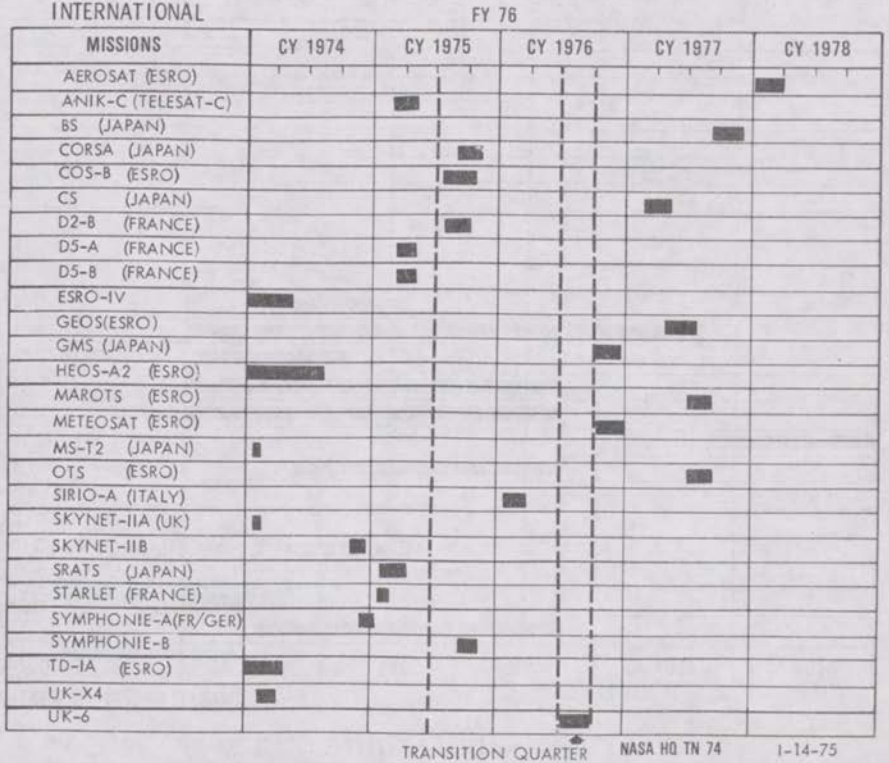
RD 11-7

SPACEFLIGHT TRACKING AND DATA NETWORK WORKLOAD

INTERNATIONAL



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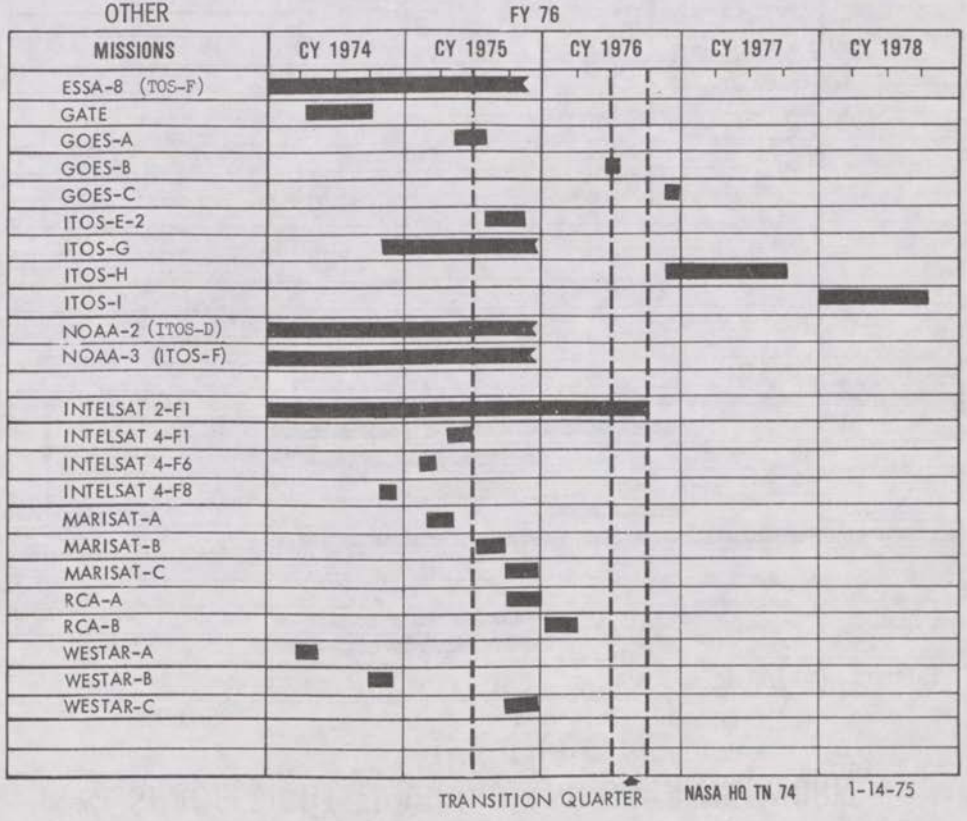
RD 11-8

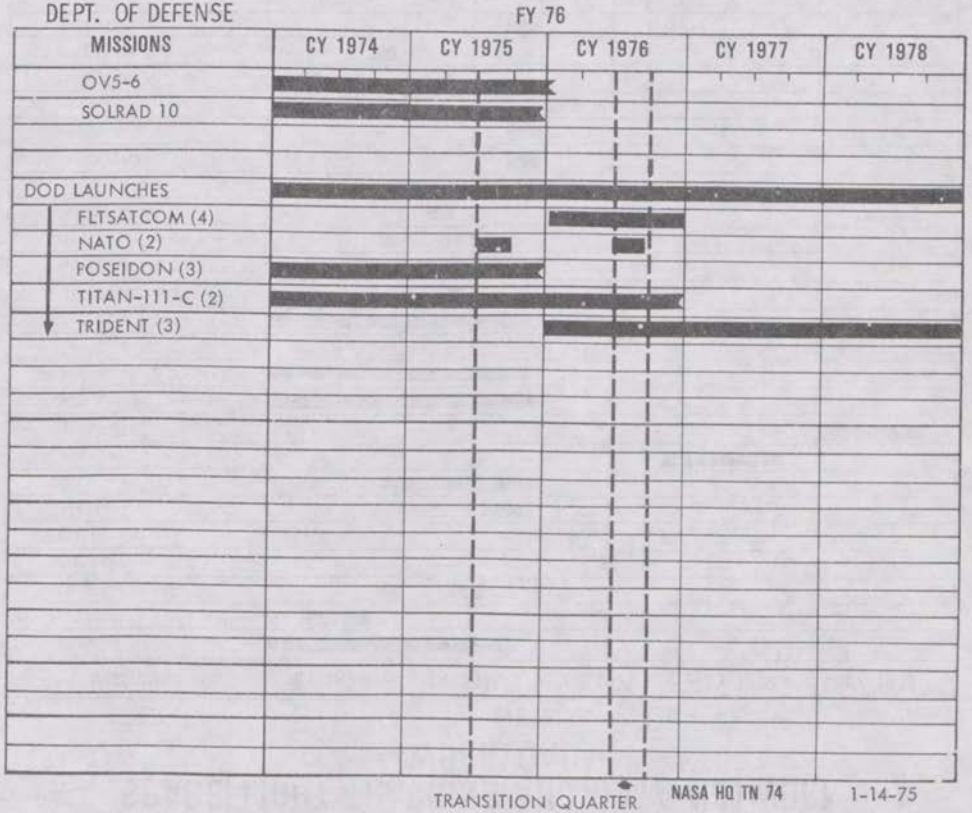
SPACEFLIGHT TRACKING AND DATA NETWORK WORKLOAD



RD 11-9

SPACEFLIGHT TRACKING AND DATA NETWORK WORKLOAD

DEPT. OF DEFENSE



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RD 11-10

Spaceflight Tracking and Data Network Operations

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$99,525	$98,200	$98,500	$97,000	$26,000

OBJECTIVES AND STATUS

The primary function of the Spaceflight Tracking and Data Network is to support manned and unmanned spaceflight missions. The majority of these missions have near earth orbits; however, the network does support missions through lunar distances. In addition, the network provides launch support to NASA's planetary missions as well as to the spaceflight missions of the Department of Defense and other U.S. agencies.

The Spaceflight Tracking and Data Network must be responsive to the tracking and data acquisition requirements of a large variety of flight projects from the time of launch to the completion of flight project objectives. In many instances the period of support required by flight projects extends to several years.

The Spaceflight Tracking and Data Network presently consists of sixteen geographically dispersed land stations, two transportable facilities, advanced instrumentation aircraft, one instrumented ship, and a control center complex at Goddard Space Flight Center. These 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 safety and other project related purposes. In addition to these electronic systems, the Spaceflight Tracking and Data Network is supplemented by laser tracking systems to meet the extremely precise needs of NASA's geodetic investigations.

The sixteen land stations are located at Fairbanks, Alaska; Goldstone, California; Merritt Island, Florida; Kauai, Hawaii; Rosman, North Carolina; Guam; Ascension Island; Canberra, Australia; Bermuda; Canary Islands; Santiago, Chile; Quito, Ecuador; England; Madagascar; Johannesburg, South Africa; and Madrid, Spain. A transportable station located near St. John's, Newfoundland, for early Skylab support has been put in caretaker status and will be reactivated in FY 1975 for the Apollo Soyuz Test Program. A second transportable facility has been relocated to Madrid for Applications Technology Satellite 6 support.

Due to changing requirements the station at Corpus Christi, Texas was closed after completion of Skylab in February 1974 and the station at Carnarvon, Australia was closed in December 1974 , after support of the Helios 1 launch. The Canary Island station will close in mid-1975 and the station near Johannesburg, South Africa will close in late 1975 after support of the launch phase of Viking.

The Spaceflight Tracking and Data Network is currently supporting on a continuing basis an average of approximately 40 unmanned scientific spacecraft including such missions as the first Earth Resources Technology Satellite (LANDSAT), several Applications Technology Satellites and Interplanetary Monitoring Platform satellites, Orbiting Solar Observatory 5, Radio Astronomy Explorer 2, Atmosphere Explorer 3, and Nimbus 4 and 5. The network is also supporting the Apollo Lunar Surface Experiment Packages (ALSEP) left on the moon's surface by the Apollo 12, 14, 15, 16, and 17 missions. Upcoming missions to be supported include Synchronous Meteorological Satellite (SMS) B, Nimbus F, Geodynamic Experimental Ocean Satellite (GEOS) C, Earth Resources Technology Satellite (LANDSAT) B, Orbiting Solar Observatory (OSO) I, and the Apollo Soyuz Test project. In addition, Atmosphere Explorer D and Atmosphere Explorer E with widely differing orbits will require simultaneous support by the network for a six month period in FY 1976. The overall workload of the Spaceflight Tracking and Data Network, which is expected to continue to average approximately 40 spacecraft during FY 1976, is indicated on the accompanying charts.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The adjustment in the FY 1975 funding level was required due to higher than anticipated cost escalation for the operation of the Spaceflight Tracking and Data Network.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Funds requested for the Spaceflight Tracking and Data Network operations in FY 1976 and the transition period are required for the maintenance and operation of the network facilities as well as the related logisitics, network support and computer programming costs associated with the around-the-clock operation of the network. The FY 1976 request reflects the decreases associated with the station closures noted above.

Deep Space Network Operations

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transistion Period
	(In Thousands of Dollars)			
$32,975	$34,600	$35,500	$38,400	$10,200

OBJECTIVES AND STATUS

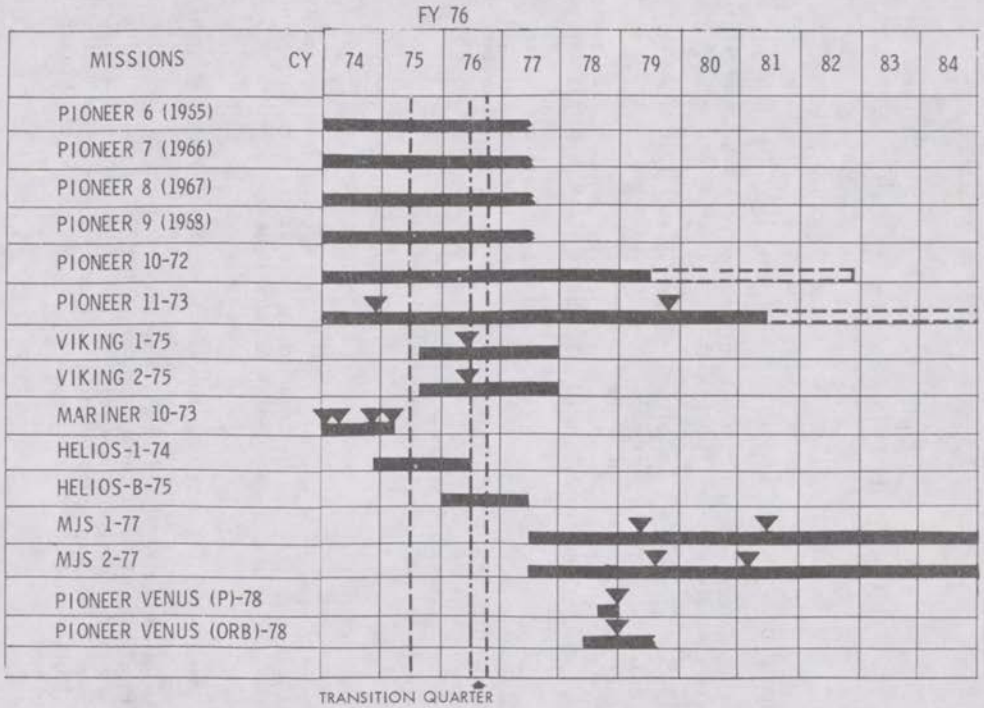
The primary fuction of the Deep Space Network is to support planetary and interplanetary space flight missions. The recently launched Helios 1 mission is on a trajectory that will take the spacecraft within forty-five million kilometers of the Sun. The Pioneer 11 flyby of Jupiter occurred December 2, 1974, and the spacecraft is scheduled to reach Saturn in the last half of 1979. The flyby of Saturn by Pioneer 11 will occur nearly 1.5 billion kilometers from the Earth. Future missions to Saturn and beyond will involve distances measured in billions of kilometers.

As missions become more complex and flight distances continue to increase, equipment designs and computer program techniques are required in this network which continue to push the state-of-the-art in interplanetary communication. The Deep Space Network provides the vital two-way communication link to these distant spacecraft by which the spacecraft are controlled and scientific data are obtained.

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 antennas at each location. The Deep Space Network station at Johannesburg, South Africa was closed in June 1974. The checkout facility at Cape Canaveral, Florida has been consolidated with the Spaceflight Tracking and Data Network station on Merritt Island, Florida.

During FY 1975, the Deep Space Network support workload consists of six ongoing Pioneer spacecraft, the Helios 1 and Mariner 10 missions. This workload, as reflected in the accompanying chart, will continue essentially through FY 1976. In addition, the Viking 1975 A and B missions will be launched in the first quarter of FY 1976. These missions will be the most complex the Deep Space Network has ever supported. The Helios B spacecraft is also scheduled for launch during FY 1976 and will add to the ongoing network workload.

DEEP SPACE NETWORK
WORKLOAD



RD 11-14

The Deep Space Network facilities are also utilized for ground-based measurements in support of experiments in the field of radio astronomy. The extra-sensitive network antennas are being used in man's attempt to learn more about such phenomena as the mysterious Quasar energy sources and the possibility of dying stars generating black holes in space. Support of these experiments will continue on a noninterference basis to the flight missions in FY 1976.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The difference in the current FY 1975 funding level from the budget estimate is due primarily to the impact of cost escalation.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

The FY 1976 funds requested for operation of the Deep Space Network facilities are greater than were required in FY 1975 due to escalation and the increasing workload associated with Viking and Helios. In addition to the mission support as indicated on the workload chart, funds are required for the engineering activities that are necessary to implement new equipment and sustain the network to meet the requirements of the Mariner Jupiter/Saturn 1977 and the Pioneer Venus 1978 missions.

The estimate for the transition period is the funding needed to continue to operate the Deep Space Network to meet operational requirements during the period from July 1 through September 30, 1976.

Aeronautics and Sounding Rocket Support

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$4,300	$5,500	$5,200	$4,100	$1,100

OBJECTIVES AND STATUS

Instrumentation systems are maintained and operated in support of the sounding rocket, small satellite and aeronautical programs conducted by Wallops Flight Center and for the flight research programs of the Flight Research Center. These instrumentation systems include general purpose fixed tracking, telemetry, data handling, recording, timing, plotting, and communications systems as well as special purpose optical equipment.

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The sounding rocket program continues to be very active with close to three hundred missions being launched last year. This workload is expected to remain approximately the same in FY 1976 with launches ranging from the smaller meteorological rockets to the larger Scout rockets. In addition to its continuing sounding rocket and aeronautical program support activities, Wallops will provide specialized tracking, evaluation and calibration services for the GEOS-C project.

The Flight Research Center operates the Aerodynamic Test Range, consisting of facilities at the Edwards Air Force Base and the up-range site at Ely, Nevada. These facilities are composed of precision radar tracking, telemetry, and communications equipments which are used to support high performance aircraft research and development programs of both NASA and the Air Force. Programs supported by the Aerodynamic Test Range include various aircraft and lifting body projects, including the F-111, F-104, X-24-B, and F-15. The Flight Research Center will also be responsible for supporting the approach and landing tests for the Shuttle Orbiter.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The difference in the current FY 1975 funding level from the budget submission is due primarily to the slippage of the GEOS-C launch date and related project support at Wallops.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATE

The FY 1976 request in this area is reduced as compared to FY 1975 due to the transfer of funding of some activities at Wallops to more appropriate programs, principally those conducted by the Office of Space Science and the Office of Applications.

The funding request for the transition period is the amount needed to continue the activities discussed above to meet operational requirements during the period from July 1 through September 30, 1976.

Communications Operations

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$32,500	$30,900	$29,900	$27,900	$7,000

OBJECTIVES AND STATUS

NASA's global communications network (NASCOM) interconnects the NASA tracking and data acquisition facilities in operational support of all NASA projects and projects of other agencies that are supported by NASA. It interconnects by means of leased voice and data circuits such facilities as telemetry and command control sites, launch areas, test sites, and mission control centers. The Goddard Space Flight Center operates the network 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 both domestic and overseas locations.

To an increasing extent the NASA flight projects are requiring higher data transfer rates between the mission control centers and the tracking sites due to the need for real time control of spacecraft and the onboard experiments. In addition, requirements for wideband communications are increasing.

In order to meet the higher data transfer rates new communications technology has been implemented in the NASA communications network such as electronic circuit switching and the capability for sending an increased amount of data over a normal voice circuit. Another development which has been implemented in the NASCOM allows for the transmission of data over a lesser number of circuits through the use of digital techniques and specially modified voice channels. This system will continue to be expanded to those NASA facilities which require this type of data and where the commercial common carriers have the capability available.

While technology developments have reduced data transmission unit costs, some additional circuits are required on a routine basis to meet the increasing workload brought about by extended mission life-times and higher data rate transfer requirements of the new flight programs. It also is necessary to augment the normal network configuration to support special mission needs such as the Apollo Soyuz Test Project, Helios, Viking 1975, and the Atmospheric Explorers D & E.

CHANGES FROM FY 1975 BUDGET ESTIMATES

The reduction in FY 1975 from the budget estimate resulted from tariff reductions for communications circuits and adjustments in program support requirements.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

The FY 1976 budget request for this operational area reflects an overall reduction from FY 1975 due to the closure of the Carnarvon, Australia,

Canary Island and Johannesburg, South Africa stations along with the continuing application of technology improvements. Funds requested will be used for the procurement of communications circuits and services required to operate and maintain the NASA communications network including the various domestic and overseas facilities.

The estimate for the transition period is the funding needed to continue the operation of the NASCOM Network to meet operational requirements during the period from July 1 through September 30, 1976.

Data Processing Operations

	1975			
1974	Budget Estimates	Current Estimates	1976	Transition Period
	(In Thousands of Dollars)			
$22,600	$23,600	$23,800	$25,000	$6,900

OBJECTIVES AND STATUS

Information received in the form of tracking and telemetry data from the various spacecraft must be processed into a form useful to both those persons controlling the day-to-day spacecraft operations and those responsible for analyzing the scientific and applications data acquired by the spacecraft. Support must be given to a wide variety of programs which vary from the small Explorer satellites to large and complex Solar and Astronomical Observatories and the Applications and Earth Resources Technology Satellites.

Tracking data are processed to provide orbital elements which are used to prepare the predictions of future spacecraft positions necessary for the real time control of spacecraft, for knowing when the spacecraft will be passing over the stations so data can be acquired, and to provide 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 mentioned above. Processed data are the primary product of the spacecraft missions, and it is through reductions and analyses of these data by the experimenters that a better understanding of earth and space is achieved.

Upcoming projects require extensive pre-mission orbit studies, including spacecraft position and attitude predictions. Studies are also required to work out operational methods and procedures to be used during the actual mission operations of these complex spacecraft.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The adjustment in the FY 1975 funding level was necessitated by higher than anticipated increases in the cost of logistics required for the operation of the data processing capability at the Goddard Space Flight Center.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

The FY 1976 budget is based upon the requirement to process data from previously launched satellites, plus additional satellites that are 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 is terminated or curtailed for older missions as mission objectives are achieved or spacecraft experiments fail. These support reductions are making possible the support of new satellites, without major increases in data processing capability. New satellites often dictate major changes in the type of support provided. For instance, the Atmosphere Explorer 3 spacecraft, launched in December of 1973, has an orbit change capability which necessitates real time orbit and attitude determination. The low altitudes reached by this spacecraft also require the near real time analysis of experiment data. This mode of operation requires that data from the stations be transmitted to the control center at Goddard Space Flight Center where it is fed directly into interconnected computers. Computations are made and scientific data are processed and placed in computer memory units. These data are used in near real time as the basis for determining commands to be sent to the spacecraft for orbit adjustment and experiment operation. Data are available to scientists for analysis within hours after initial data acquisition by the ground stations. Two additional spacecraft of this type will be launched in 1975, and simultaneous operation of two or more such spacecraft will be required during FY 1976.

The Image Data Processing Facility, established for the support of the first Earth Resources Technology Satellite (LANDSAT - 1), will continue operation in support of the new LANDSAT-B spacecraft in FY 1976. This facility is expected to continue operations through the next several years, at approximately the same level of effort, to support the continuing Earth Resources program.

The estimate for the transition period is based upon the continued operation of the data processing facilities and the projected computer and software support required during the period from July 1 through September 30, 1976.

Systems Implementation

The objectives of the NASA networks 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 NASA tracking and communications networks, control centers, data processing facilities and aeronautics and sounding rocket instrumentation.

The systems instrumentation 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 development of initial computer programs as applicable, the provisioning of initial and large module spares, and associated services such as acceptance testing, integration and checkout of subsystems and systems.

Funds are required to maintain adequate operational performance and reliability of network systems by providing for the replacement of obsolete and worn-out equipment, the modification and augmentation of existing systems to maintain compatibility with changes in associated onboard spacecraft communications systems and the improvement of support utilization and efficiency of network systems.

Funds are required in FY 1976 and the transition period for the implementation of new capabilities including those necessary for network system augmentation for the Mariner Jupiter/Saturn 1977, Pioneer Venus, Shuttle, International Ultraviolet Explorer and High Energy Astronomy Observatory missions. In addition, funds are required for the modification and augmentation of the data processing facilities to provide increased accuracy and resolution in image processing for such missions as NIMBUS-G, SEASAT-A, and Heat Capacity Mapping Missions.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(In Thousands of Dollars)			
Spaceflight tracking and data network.....	$ 19,400	$ 25,600	$ 19,300	$ 17,400	$ 5,100
Deep space network.....	$ 13,283	$ 12,000	$ 12,800	$ 14,300	$ 5,400
Aeronautics and sounding Rocket support.....	3,007	3,300	3,100	2,700	700
Communications.....	2,274	3,200	3,200	3,000	800
Data processing....	4,936	3,900	3,900	4,000	900
Total.....	$ 42,900	$ 48,000	$ 42,300	$ 41,400	$12,900

Spaceflight Tracking and Data Network Systems Implementation

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$19,400	$25,600	$19,300	$17,400	$5,100

OBJECTIVES AND STATUS

During FY 1976 the network will continue to support approximately forty spacecraft on an around-the-clock basis, including many ongoing missions with highly complex requirements -- such as Applications Technology Satellite 6, Earth Resources Satellites (LANDSAT) 1 and B, Atmosphere Explorer C, and Synchronous Meteorological Satellites. In addition to supporting ongoing missions, the network will also provide support to a number of new missions. Among those are the Apollo/Soyuz Test Project, the Geodynamic Experimental Ocean Satellite C, the NIMBUS-F, the Orbiting Solar Observatory I, the Atmosphere Explorer D and E, and the Small Astronomy Satellite C.

The Spaceflight Tracking and Data Network systems implementation program encompasses the procurement and implementation of systems and services necessary to sustain the network's continuing capability for reliable support to these ongoing scientific and applications satellite missions, to provide network capabilities to assure efficient and multipurpose tracking, command, and data acquisition support for all manned and unmanned earth orbital and synchronous missions, and to meet new support requirements for spacecraft to be launched in the near future.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The adjustment in the FY 1975 funding level from the budget estimate resulted from the agency requirement to reduce the operating level for the agency to the appropriated amount and to provide funding for the Phase I contract effort for Tracking and Data Relay Satellite System. To accommodate these requirements it is necessary to stretch out procurement of the laser systems planned for support of LAGEOS and other elements of the Earth and Ocean Physics Applications Program. The impact of deferring the lasers is to restrict the investigation of earth surface phenomona, thereby delaying the understanding of any correlation between earth surface motion and earthquakes.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Equipment modification is required in FY 1976 to maintain the network's required high level of performance for support of its diverse and demanding workload and to assure the quality and reliability of the network's systems and subsystems. Accordingly, funds are requested 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. Funds are also requested for subsystems spares, for provision and modification of test equipment, and for minor equipment modifications resulting from changes in support requirements from one mission to the next.

Network system augmentations are planned for support of the approach and landing and orbital flight test phase of the Space Shuttle program. Digital voice demodulation systems will be provided at certain core network stations for relaying voice between the Space Shuttle and the mission control center. In addition, command, telemetry and voice communications equipment will be procured for installation at the Space Shuttle primary landing sites to support the terminal phase of each flight.

Funds are also requested for implementation of the displays, consoles, and computer peripherals necessary to complete the control center for the International Ultraviolet Explorer. Control center modifications to the existing Orbiting Astronomy Observatory control center for the High Energy Astronomy Observatory include console replacements, display and computer modifications, and provision of additional communications interface equipment. In addition, some improvements and augmentation to laser tracking systems necessary to support the LAGEOS satellite and other elements of the Earth and Ocean Physics Applications program are included in the FY 1976 funding request.

The estimate for the transition period is the funding required during the period from July 1 through September 30, 1976 to sustain the network capabilities and to continue the implementation of capabilities for support of ongoing and approved programs.

Deep Space Network Systems Implementation

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$13,283	$12,000	$12,800	$14,300	$5,400

OBJECTIVES AND STATUS

The Deep Space Network systems implementation program provides for the procurement of equipment and related services to sustain the network's capability to provide support to the ongoing planetary spacecraft missions and to procure the necessary equipment and augmentations required in the network to support the upcoming launches of approved planetary flight missions.

Due to the extreme distances of planetary spacecraft from earth very large antennas and extremely sensitive and complex receiving and data handling equipment must be used at the ground stations to provide communications with the spacecraft. Consequently the network systems require a continuing effort of replacement, modification and augmentation to maintain a high degree of reliability and operational integrity and to incorporate state-of-the-art improvements in telecommunications which are the key to achieving and maximizing the scientific return from these missions.

CHANGE FROM FY 1975 BUDGET ESTIMATE

The adjustment in the FY 1975 budget estimate for the Deep Space Network Systems is due primarily to the increased funding requirements resulting from the refinement of support requirements for upcoming approved missions such as Viking and Mariner Jupiter/Saturn.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

In support of the ongoing planetary missions, such as Pioneer 10, Pioneer 11 (now targeted to fly by Saturn in 1979) and Helios, network system modifications and equipment replacements will be necessary to assure longer term network reliability and operational integrity. These missions are characterized by time critical support demands on the network involving

spacecraft attitude maneuvers, mid-course trajectory changes, and encounter sequences which dictate an extremely high level of system reliability that can only be achieved with a continuing program of module and component replacement and readily available spare modules and components. Funds are requested in FY 1976 for replacement hardware and spares so that the network systems can provide uninterrupted support to these extended ongoing missions and to incorporate changes to maximize the scientific return of these missions.

Preparations for Viking support are currently underway and in FY 1976 the network will be providing extensive support for the cruise phase of the mission. Concurrently, final system preparation will be completed to support the Mars Orbiter and Lander Phase of the mission. Since the Viking mission will be the most complex one ever supported by the network, extremely high precision and performance levels must be met by the network systems.

In preparation for the dual Mariner missions to Jupiter and Saturn in 1977, long lead time development of prototype equipment has been initiated in prior years. Equipment changes include those needed to accommmodate the increased command transmission data rate required by the spacecraft computer in order to update the many critical stored programs. These programs are used not only to control the numerous spacecraft functions but also to change the telemetry data rate and data content in accordance with variations in mission operations sequences.

Other equipment changes include those required to receive the new X-band (8400 megahertz) telemetry transmissions from the spacecraft and handle a new coded telemetry system capable of transferring the large quantities of vital science and engineering data with minimal error during the planetary flyby phases which will occur at distances beyond 1 1/2 billion kilometers (9.5 A.U.) from earth.

In addition, to precisely control the spacecraft trajectory for close flyby to the planets and their selected satellites, increased ground system navigation capabilities are required. These will be provided by augmenting the tracking equipment with special recording, processing and timing systems to allow measurement of spacecraft position and velocity over the great communication distance from two widely spaced earth stations simultaneously. In FY 1976, as part of a time-phased implementation program, it is planned to provide equipment to stations of the Deep Space Network which will be used for early prelaunch testing with the spacecraft and for launch and early cruise support. Accordingly, funds are requested to initiate systems implementation for support of the early phase of the Mariner Jupiter/Saturn missions.

The estimate for the transition period is the funding required from July 1 to September 30, 1976 to sustain the network for ongoing mission support

and to implement the network, in a timely manner, for the Mariner Jupiter/ Saturn mission which is scheduled for launch in 1977.

Aeronautics and Sounding Rocket Support System Implementation

1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Peroid
	(In Thousands of Dollars)			
$3,007	$3,300	$3,100	$2,700	$700

OBJECTIVES AND STATUS

The aeronautics and sounding rocket programs are supported at the Wallops Flight Center in Virginia and the Flight Research Center in California.

The aeronautics program supported at Wallops consists of space component tests utilizing helicopter or aircraft drops, aircraft noise abatement projects, slow speed landing techniques for jet aircraft, anti-skid tests on grooved runways, 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 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 an orbital launch capability. The experiments are launched not only from Wallops Island but also from remote sites around the world.

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 onboard 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 foreign nations including Argentina, Brazil, and Spain.

The aeronautical programs supported by the Flight Research Center (FRC) consist of high altitude and terminal area tests involving high performance

aircraft and lifting bodies such as the F-111, X-24B, YF-12, 747 Shuttle Carrier, and various other aircraft and helicopters. The FRC also will be responsible for the approach and landing tests for the Shuttle Orbiter. The ground support equipment is located on the Aerodynamics Test Range which consists of stations at Edwards, California and Ely, Nevada. 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.

CHANGES FROM FY 1975 BUDGET ESTIMATE

The adjustment in the FY 1975 funding level resulted from changes in support requirements at Wallops Flight Center and the Flight Research Center.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Funds are requested in FY 1976 to provide the sustaining equipment and modifications necessary to support the sounding rocket and aeronautics programs.

The estimate for the transition period is the funding needed to continue these activities to meet operational requirements during the period from July 1 through September 30, 1976.

Communications Systems Implementation

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$2,274	$3,200	$3,200	$3,000	$800

OBJECTIVES AND STATUS

Funds requested for communications equipment are used for the procurement of hardware for the NASA communications network to meet new program support requirements, to increase the efficiency of the network and to sustain the network at a high level of reliability.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

In FY 1976 modifications will be made to the existing systems as part of a continuing program to increase the amount of data that can be transmitted over existing circuits. Another modification effort will provide the capability for transmitting bulk data over a specially modified voice circuit in lieu of using multiple circuits to transmit the same data.

To maintain system reliability a continuing program to procure replacement parts, spares, test and monitoring equipment is necessary. This hardware assures that the data circuits can be maintained within prescribed limits, thus ensuring the necessary level of system reliability.

For the transition period the funds requested will provide for the continuation of the efforts discussed above to meet ongoing program requirements and to sustain the network at the required level of reliability.

Data Processing Systems Implementation

	1975			
	Budget	Current		Transition
1974	Estimate	Estimate	1976	Period
	(In Thousands of Dollars)			
$4,936	$3,900	$3,900	$4,000	$900

OBJECTIVES AND STATUS

The FY 1976 estimate includes funds to modify and augment the existing NASA image data processing facility at the Goddard Space Flight Center in order to meet the image accuracy and resolution requirements of upcoming approved missions. Initially, this facility was established for the Earth Resources Technology Satellite (LANDSAT) 1 and B missions and operated as an analog system doing the great majority of data manipulation within the photographic process itself. The accuracy requirements for experiments on future spacecraft including NIMBUS-G, SEASAT-A, and the Heat Capacity Mapping Mission are such that the data must be processed in digital computer compatible form.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

With the augmented system digital data acquired by the network stations will be entered into computers for processing and data correction in digital form. This will provide higher quality data by a factor of two to three over the present approach. The product of this process will be high density digital tapes. The augmented facility will be general purpose in nature, meeting the processing requirements of the above mentioned missions and possibly the extended phases of the LANDSAT B mission.

In addition, funds are required in FY 1976 to maintain the existing scientific data processing systems. Typical of these activities are (1) modifications to the existing computer complex to facilitate interconnection with the many peripherals associated with its operation including drums,

displays and line printers; (2) the addition of power source monitors and (3) the purchase of routine and special spare components and hardware.

The estimate for the transition period is the funding needed for continuation of the activities discussed above to meet operational requirements during the period from July 1 through September 30, 1976.

Advanced Systems

The OTDA Advanced Systems program, formerly designated Supporting Research and Technology, includes studies and developments of tracking and data acquisition systems and techniques required (1) to provide new and improved network and data processing capabilities to meet the needs of approved missions and new starts; and (2) to improve the cost-effectiveness and reliability of the overall T&DA support for the total mix of NASA flight missions. This effort includes spacecraft and ground system trade-off studies aimed at optimizing space-to-ground telecommunications links.

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
$9,200	$9,200	$9,200	$9,200	$2,300

OBJECTIVES AND STATUS

The program to meet the above objectives for FY 1976 is comprised of activities in four basic areas:

1. Tracking, orbit determination and ground-based navigation
2. Spacecraft/ground communications, telemetry and command
3. Network control and operations technology
4. Data handling and processing

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES

Studies and developments will proceed in the area of tracking and ground-based navigation for support of future planetary missions. New and improved tracking techniques, using simultaneous data from more than one station in a Very Long Baseline Interferometry (VLBI) mode, will be investigated.

These techniques are also being studied as a method to determine spacecraft position against a background of extraterrestrial radio sources, known as quasars. This technique will greatly reduce errors that now limit the accuracy achievable in spacecraft tracking. Time synchronization among network stations with atomic timing standards will continue to be investigated in order to meet the extremely accurate tracking requirements of future missions. Development effort will also continue in FY 1976 on a general purpose approach to meet spacecraft attitude determination and control system requirements, in order to utilize common software and achieve greater efficiency in the data processing function than is now obtained with the present multiple attitude determination systems.

Radio telecommunications techniques will continue to be developed in FY 1976 in order to provide reliable and economical support of future spacecraft command and data acquisition requirements.

Future planetary missions will require data rates in excess of 100 kilobits per second from the vicinity of Jupiter, approximately 900 million kilometers away. Studies will continue on the influence of transmission media, such as the sun's corona, planetary atmospheres and space charged particles, on such deep space communications. The capabilities of our large aperture antennas will be further improved by the use of higher frequencies, the development of techniques for arraying several antennas, the study of dish-surface shaping, and by development of low radio noise elements coupled with receivers having improved sensitivities.

Future earth orbital missions require an order of magnitude improvement in the rate at which data must be acquired and handled, i.e., approximately 300 million bits per second for high resolution image data. Effort is required on ground antenna feed systems and telemetry receivers as well as on network station techniques for handling high data rates. Network support analyses will be made to plan for support of future missions such as the Large Space Telescope and the Earth Observation Satellite.

Effort will continue on techniques for centralized control and monitoring of tracking and data acquisition support operations both at the stations and their respective network control centers. The objective is to obtain greater efficiency and effectiveness in the utilization of the overall network systems. Features for automated monitoring and control will be examined and developed for those applications which are determined to be cost effective and necessary to meet real time operations requirements. Techniques for multiple use of minicomputers to monitor and control network functions and to improve logistical support and reduce manual operations in the network will continue to be pursued. Work also will be continued in FY 1976 to develop and apply new techniques necessary to maintain low cost, reliable software.

Studies and development will be conducted on data handling and data processing systems and techniques to meet the increasing requirements for real time mission control and user-interactive information systems. Our studies will be concerned particularly with the problems of high rate, on-line data handling, storage, and retrieval; and also with techniques and systems for a fully digital approach to handling of imaging data from earth observation satellites.

The funds requested for the transition period are required to continue the developments and studies in the areas discussed above during the period from July 1 to September 30, 1976.

Tracking and Data Relay Satellite System

A major aspect of the Tracking and Data Acquisition Program in future years will be the Tracking and Data Relay Satellite System (TDRSS).

The TDRSS will consist of two specialized relay spacecraft and a ground terminal in the continental United States, and will serve to relay data, commands and voice to and from mission spacecraft and the ground control center. The two relay spacecraft will be positioned in geosynchronous orbit, one over the mid-Atlantic Ocean and the other over the mid-Pacific Ocean. A spare relay spacecraft will be positioned in orbit midway between the two active spacecraft.

	1975			
1974	Budget Estimate	Current Estimate	1976	Transition Period
	(In Thousands of Dollars)			
---	---	$3,600	---	---

OBJECTIVES AND STATUS

The TDRSS will support essentially all earth orbital spacecraft missions and will greatly improve NASA's earth orbital tracking and data acquisition capabilities. Since the TDRSS will support essentially all earth orbital spacecraft missions, it will permit the eliminiation of many of the ground stations in the present Spaceflight Tracking and Data Netwrok with resulting cost savings.

NASA is planning to acquire this capability through a contract for services arrangement: that is by entering into a contract under which the contractor will establish the system and provide NASA with service for a period of ten

years. Under this contract for services arrangement, NASA funding for services will not be required until service actually commences in FY 1979.

The schedule for development and construction of the TDRSS is based upon having a fully operational system by early 1980, in time for support of the Space Shuttle operational flights.

CHANGES FROM FY 1975 BUDGET ESTIMATE

Since last year, NASA has decided to use a competitive two-phase procurement approach to acquire TDRSS service. Phase I will involve the award of multiple study contracts for definitive system design and technical and cost proposals. Phase II will involve the competitive selection of a single contractor for final design, implementation and operation.

The difference in the current FY 1975 funding level from the budget estimate represents the amount that has been reprogrammed to fund the Phase I contracts. These funds are a part of the NASA deferral actions included in the President's Special Message on Budget Restraint (November 26, 1974). These deferred funds will be used for the Phase I contracts in early FY 1976. No additional funding requirements are anticipated until TDRSS service begins in FY 1979.

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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1976 ESTIMATES

BUDGET SUMMARY

OFFICE OF INDUSTRY AFFAIRS AND TECHNOLOGY UTILIZATION

TECHNOLOGY UTILIZATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Industrial applications....	$1,985	$2,900	$2,900	$3,220	$850
Technology applications....	1,845	2,000	2,000	3,025	950
Program control and evaluation.....	670	600	600	755	200
Total.....	$4,500	$5,500	$5,500	$7,000	$2,000
Distribution of Program Amount by Installation:					
NASA Headquarters.....	$4,500	$5,500	$5,500	$7,000	$2,000

OBJECTIVES AND STATUS:

New advances and innovative technologies resulting from aerospace research and development programs are transferred and applied to non-aerospace needs through the NASA Technology Utilization program. Since its inception the Technology Utilization program has been instrumental in linking NASA/aerospace technology to additional uses in the nation's industrial and public sector communities through a variety of established and proven transfer mechanisms. With each passing year NASA has strived to make these mechanisms more effective by strengthening interactive relationships with the non-aerospace user communities.

In FY 1976, the Technology Utilization program plans to broaden its capability to transfer aerospace technology to meet technological needs in certain U.S. geographical areas which have heretofore been difficult to serve. Since the current NASA Industrial Application Centers (formerly known as Regional Dissemination Centers) are somewhat limited geographically due to cost constraints and operational considerations, NASA proposes during FY 1976 to institute an "outreach program" that will enable the IAC's to

effectively serve new user markets in cities of high industrial concentration (e.g., Chicago, Atlanta, Seattle, etc.). IAC Divisional Offices to be established at these and other sites will provide greater insight into the technological needs of industry in those regions, and will also provide a more viable and substantive base for interaction with State and local governments.

At the same time, NASA plans to further strengthen interactive ties between public and private users and the problem-solving capabilities of aerospace technologists located at the various NASA Field Centers. The anticipated growth in problem-solving opportunities in FY 1976 will require additional emphasis in applications engineering in order to demonstrate the feasibility and application of NASA-derived technologies to public sector needs. NASA experience in technology transfer indicates that these outreach efforts will materially enhance and effectively multiply the resultant transfer and use of aerospace technology in the U.S. industrial and public sectors.

CHANGES FROM FY 1975 BUDGET ESTIMATE: None.

BASIS OF FY 1976 AND TRANSITION PERIOD ESTIMATES:

Industrial Applications

Pursuant to Section 305(b) of the National Aeronautics and Space Act of 1958, Technology Utilization Officers at all NASA installations identify new technology developed by NASA and its contractors which has potential utility for non-aerospace application and use. New advances identified in such diverse fields as materials research, communications, bio-engineering, and fabrication/manufacturing technology, are evaluated and published in NASA Tech Briefs, Compilations, Handbooks, and other dissemination media. In FY 1976 and the subsequent Transition Period, special emphasis will be directed toward increased market relevance of the technology and improved distribution methods to broaden availability and use.

During FY 1976 and the transition period, NASA will also continue to move forward toward an interactive network of Industrial Application Centers. The current six Centers will form the basis of the IAC network. These six are presently unable to effectively interact with industrial communities outside their immediate respective geographical locations due to the costs of extended travel. It is proposed that IAC Divisional Offices be established in FY 1976 to extend in a cost-effective manner the visible outreach of NASA's technology transfer efforts and its support to industry. Divisional Offices are being considered for highly industrialized urban areas, such as the San Francisco Bay Area, Houston, Chicago, Atlanta, and/or St. Louis. The foregoing fully supports the program intent of developing a national

network of technology transfer centers to serve the technological needs of U.S. industry as well as State and local governments. More specifically, these Divisional Offices in conjunction with parent Industrial Application Centers will provide an operable framework and structure to facilitate the use of established and proven transfer mechanisms (e.g., conferences, seminars, etc.) for selected user groups located in strategic geographic areas.

Public sector problems identified in cooperation with user agencies are matched with existing aerospace technology via Application Teams, Industrial Application Centers, and NASA Field Centers. This matching process gives rise to specific applications projects designed to adapt, modify, or otherwise re-engineer existing NASA technology to meet performance requirements specified by Federal, state or local user organizations. Currently, upwards of seventy active applications engineering projects are underway at eight NASA Field Centers and at NASA Headquarters.

The major emphasis of the engineering projects has been placed in biomedical applications in the specific areas of detection, diagnosis and treatment, instrumentation, rehabilitation, and biomedical systems analysis and health planning. The areas of urban construction, fire safety, environmental pollution and transportation will continue to receive attention via the sponsorship of applications engineering projects. In response to identified needs in the public sector, projects concerned with mine safety and public safety were initiated during FY 1975 and it is expected that continued emphasis will be placed on these endeavors in FY 1976.

Program Control and Evaluation

NASA will continue its efforts to document and analyze specific evidence of technology transfer as a means to (1) a better understanding of the transfer process, and (2) effective modification to existing transfer mechanisms and programs. Such factors as time lag, industrial receptivity, technology matching characteristics, etc., will be analyzed and evaluated to determine relative impact and effectiveness of NASA's technology transfer efforts.

Further efforts will be continued in FY 1976 to document impacts and benefits (technological, societal and economic) of NASA R&D programs and their respective influence on the nation's capabilities and future growth. Such efforts are intended to provide greater insight to furthering the use of Federally sponsored R&D through technology transfer and application programs.

SHUTTLE BUDGET REQUEST

Mr. BOLAND. You are requesting $1,206 million for the Space Shuttle in fiscal year 1976 and $321 million for the transitional period. What was your request of OMB for the Shuttle in fiscal year 1976 and the transition period?

Mr. LILLY. It was $45 million more than this fiscal year 1976 budget request, Mr. Boland.

Mr. BOLAND. So you requested $1,251 million for that program, correct?

Mr. LILLY. Yes.

Mr. BOLAND. What about the transition period?

Mr. LILLY. There was no adjustment in the transition period.

SHUTTLE SCHEDULE

Mr. BOLAND. Does that $45 million reduction delay the program beyond what was planned for fiscal year 1975?

Mr. LILLY. No, sir, it does not. We still plan to have the first manned orbital flight in 1979. There were certain adjustments that had to be made. We conducted a comprehensive requirements review on types of adjustments we could make, such as certain deletions of test articles and deferrals of certain items. That is how we were able to come down by the $45 million. There was no adjustment made to the dates for the orbital rollout or for the first manned orbital flight.

FISCAL YEAR 1977 SHUTTLE FUNDING FORECAST

Mr. BOLAND. What is the current estimate for fiscal year 1977 funds? What will you require for the Shuttle in fiscal year 1977?

Mr. LILLY. For fiscal year 1977, our current forecast, without the impact of inflation, would be $1,276 million.

NEED FOR APPROVAL OF SHUTTLE BUDGET REQUEST

Mr. BOLAND. If the Congress reduces this program by $50 million in 1976, how would you make these economies and still keep the time schedule or could you? Obviously you were able to do it with a $45 million reduction that OMB handed you.

Dr. FELTCHER. We really had to cut and scrape to live within the $45 million cut. Although safety and performance are not compromised, the adjustments did add a minimal, but we think manageable, technical risk to the program.

For example, we actually cut out some training hardware. We reduced the wind tunnel test program. We cut out some of the pieces of development hardware, such as two engine controllers. We cut out a number of pieces of hardware to absorb that $45 million cut.

As I indicated earlier, we feel that we can still meet our commitments, based on our progress to date.

But to make a much deeper cut than the $45 million would be a serious blow to the Shuttle development program. It would not only disrupt the entire development program, but would also cause extremely costly schedule delays.

STATUS OF FISCAL YEAR 1975 SHUTTLE OBLIGATIONS

Mr. BOLAND. How much of the $800 million that you requested for the Shuttle in fiscal year 1975 has been obligated through the end of January?

Mr. LILLY. The amount obligated on the Shuttle through the end of January was $635 million.

Mr. BOLAND. When will the rest be obligated?

Mr. LILLY. The balance will be obligated between now and the end of the fiscal year, the majority within the next 3 months.

PROGRAM CONTINGENCY PROVISIONS

Mr. BOLAND. Do most of the NASA programs have contingencies built into them?

Mr. LILLY. When we undertake a large R. & D. program such as the Shuttle, in terms of coming up with an overall estimate, we do provide for what we consider to be reasonable contingencies. We do that in any major flight program or project we undertake. To the degree that there are technical uncertainties, we provide some amount in the overall program for contingencies.

You will note that in many cases we will give you the estimated cost of a project in a range, for example, $170 million to $190 million. In most cases, the difference is the allowance for program adjustments or technical uncertainties. How this usually works, Mr. Chairman, is that you consider this when you originally start a program. In any R. & D. program, there are certain technical uncertainties as you move along in development.

There is a provision for known or anticipated change orders on a contract. But the normal contingencies for the real technical uncertainties are usually downstream from where you are.

SHUTTLE CONTINGENCY

Mr. BOLAND. What is the level of the Shuttle contingency?

Dr. FLETCHER. The amount of contingency in the out-years is not made public because of the competitive nature of our contracts. We don't want potential contractors to know our contingency reserves or their bids would be higher. We will be glad to discuss the contingency funds in private with the subcommittee.

Mr. BOLAND. Have you used any of the Shuttle contingency funds to date?

Dr. FLETCHER. Yes; we have. We are using it as we go along, as Mr. Lilly points out. It is always small in the year just ahead. In the the year after that, it gets bigger. We have to balance total program requirements and accommodate necessary changes in the program to meet the schedule.

Mr. LILLY. Mr. Boland, if I may add one other point since you were talking in terms of total program. I was discussing contingencies in terms of an R. & D. program. In the construction of facilities program, there is always a provision for contingency. Depending on the uncertainty, it usually ranges anywhere from 7 to 10 percent.

SHUTTLE MAIN ENGINE PROBLEMS

Mr. BOLAND. With respect to the Shuttle contingency, was any of it used on the problems involving the main engine?

Mr. LILLY. Yes; in terms of the total cost of the Shuttle, the main engine eats into some of the contingency.

SHUTTLE ORBITER CHANGES

Mr. BOLAND. You apparently have had to make some changes in the orbiter since last year, particularly in the thermal protection system area. What were these changes, why were they needed and how did they impact on costs?

Dr. FLETCHER. John Yardley will answer that question.

Mr. YARDLEY. I am not aware of any significant changes. We were having some developmental difficulties with the insulation that we used on the orbiter this time last year. We made changes in the sense that we were able to find better sources for the sand. We made changes in that we changed our processing techniques, so we could get good material consistency. We have been through that hurdle. We developed satisfactory external coatings for the thermal protection system but the basic concept of the system has not changed.

SPACELAB

Mr. BOLAND. As Dr. Low indicated, the Europeans are building the Spacelab. The Spacelab will be carried in the Shuttle cargo bay and will be used for scientific experiments in space. Will the lab be ready for the Shuttle when it becomes operational in 1980?

Mr. YARDLEY. Yes, the European schedule to deliver the first Spacelab to us is 1 year prior to the first operational flight date of the Shuttle. That should give us plenty of time to check it out, et cetera.

Mr. BOLAND. How much are the Europeans investing in the Spacelab?

Mr. YARDLEY. Their estimate right now is $420 million.

Mr. BOLAND. How many Spacelabs will NASA buy and at what cost?

Mr. YARDLEY. We have not finalized that yet. Our present thinking is that we will probably require at least two labs. A Spacelab can consist of either the small module alone or the small module plus an extension module or a number of pallets. Our requirements now are the equivalent of two labs, plus some additional ground support equipment.

We have not finalized the costs with the Europeans on this. They are just getting their design started, so we cannot say for sure.

Dr. FLETCHER. We have obligated ourselves to purchase one. They are going to give us the first one free. We are currently committed to buy at least one additional Spacelab.

That is our current commitment. We have no specific estimate yet of how many of these we will purchase downstream. We cannot really estimate that until the payload model is more fully refined.

Mr. BOLAND. What is the largest lab that the cargo will carry?

Mr. YARDLEY. The large module consists of both the service module and the extension module. It is about 20 feet long. Then you also have pallets that you can put on.

The pallets are in a nonpressurized area where you can mount instruments external to the Spacelab that can be controlled from inside.

SPACELAB PROGRESS

Mr. BOLAND. Do you have any present problems with the Spacelab? Are there any problems at all connected with it?

Mr. YARDLEY. No. The Europeans, of course, are just getting started. They selected a prime contractor last summer.

SPACELAB CONTRACTOR

Mr. BOLAND. Who is the prime contractor?

Mr. YARDLEY. The prime contractor is V.F.W. Fokker, the Erno Division in Bremen, West Germany. They are the prime contractor and there is a consortium of 10 European countries, each of which has a part of the Spacelab in a subcontract form.

The only problem I would say is getting all the requirements settled and getting the design frozen so that they can move on out. Right now there is a lot of activity in that area.

PURPOSE OF SPACELAB

Mr. BOLAND. Mr. Traxler.

Mr. TRAXLER. Could you tell us briefly about the Spacelab? What is its purpose, how many people will you have in it, and what is it going to do?

Mr. YARDLEY. It is a facility or laboratory that fits in the cargo bay of the Shuttle and provides a pressurized area, breathable atmosphere, temperature control, power, and a data system. It provides a universal laboratory, you might say, which can be outfitted for any one of many purposes. For example, it can be outfitted for life sciences experiments by slipping drawers into racks. After returning from such a mission, the next time it can serve as a space sciences lab or a multiple purpose lab. The purpose of the Spacelab is to provide a very low cost, reusable space station capability that is very flexible in terms of what you are doing in any one flight.

It also takes a minimum of leadtime between the point that you decide you want to put something on it and the time you actually fly.

Dr. FLETCHER. You might say it can be used for a mixture of payloads. And, of course, the passengers—scientists and technicians—will be both males and females.

Mr. YARDLEY. There is no finite limit on the number of people in the Spacelab, generally three operating it at one time are comfortable. We can carry seven in the Shuttle and you can have two shifts this way.

SPACE PROCESSING POTENTIAL

Mr. BOLAND. Will you be developing or producing manufactured products in space?

Mr. YARDLEY. Yes, that is one of the major purposes of the Spacelab. It can do applications work, too.

Mr. BOLAND. You indicated to the committee last year, as I remember, that one of the areas in which the Space Shuttle might very well pay for itself is in the area of crystals. Would you like to expand on that?

Dr. FLETCHER. I think I ought to answer that one, Mr. Chairman. There are various kinds of space processing, that are being looked at in terms of commercial uses. The first is crystal growth. You can grow much purer crystals in space than you can on Earth because there is no interference from gravity and, therefore, no convection. We have already experimented with crystal growth in Skylab. We can talk about what these crystals can be used for in a moment.

The next process that looks promising is the production of new alloys, alloys that cannot be made on Earth but can be made in space. This is because different kinds of metals will not mix on Earth. They separate out, whereas under zero gravity, they do not separate out.

Another class of experiments that looks promising and may be an even greater payoff in the long run is the separation of biological material, particularly serum used for protection against disease. We can make purer serum in space because of the lack of gravity. Serum production may well be the most significant returns from the Shuttle/Spacelab. If you put all this together, people are making forecasts now as to what kind of commercial sales are possible downstream.

The estimates by business people, not NASA people, range from $1 billion a year worth of business up to $2 billion of business a year, depending on how things develop.

Mr. TALCOTT. You did not include ballbearings, which was one of the big ones last time.

Dr. FLETCHER. I did not include that even though it is a distinct possibility. The ballbearing experiment on Skylab was not as successful as we had expected. They were round but not as round as anticipated.

SPACELAB STEPPING STONE TO SPACE STATION

Mr. TRAXLER. Don't we ultimately come to the space wheel of 2001 as a permanent thing?

Dr. FLETCHER. The Spacelab is the next step toward a space station. It is a giant step. I don't want to say 2001, but it will be a step toward a permanent space station. Some day we will have a permanent space station. Maybe the Soviets will have it before we do, but the Spacelab is a good start toward a permanent space station.

PROCESSING OF ALLOYS

Mr. BOLAND. There is no problem with the formation of alloys in space. Is there any problem with them separating out when they get back to Earth?

Dr. FLETCHER. No. It works like this, Mr. Chairman. Take some gasoline and water and shake it up. Pretty soon the gasoline goes to the top and the water goes to the bottom. If you did that in space they would stay mixed. If you were to freeze it in space, as you would

metals, and then bring it back to Earth, they would stay mixed as they did in space. I am sure that certain kinds of alloys have a tendency to "creep" and, they might tend, over the decades to separate. But if it is a good alloy, it would not separate out on Earth once it is made.

SHUTTLE STRATOSPHERIC EFFECTS

Mr. BOLAND. If you used that alloy on aircraft, you might get metal fatigue.

What about the threat of the Shuttle to the ozone layer? You talked a little about that subject this morning. Of course, the Shuttle is not alone in this area. You have Freon and SST considerations under study. In the 1980's there will be one or more Shuttle launches each week. What impact does the Shuttle have on ozone?

Dr. FLETCHER. We got interested in the ozone problem because of the possible effects of the Space Shuttle on the ozone layer, because it does emit chemicals that could conceivably have an impact.

All the calculations so far, however, indicate that the HCl, hydrochloric acid, emitted by the 700 Shuttle flights over the 12-year period has a very small fraction of 1 percent impact on the ozone layer, which is much less than some of the other effects we have been talking about, such as Freon or high-flying aircraft. The latest concern in terms of pollutants is bromine. That is an industrial chemical that experts are beginning to think has a greater impact on the stratosphere than Freon.

The main point, though, is that there are many chemicals that possibly could contaminate the stratosphere. We feel we have to measure these. That is why we became involved in the program to measure stratospheric effects. We have a comprehensive program to find out what the chemical processes that might contaminate the stratosphere are.

So far, the Shuttle effects are not a problem. If it is 1 percent, we can measure it. We are working on a backup program, using a different chemical that is more expensive, but we would use it if the effects seem to be larger than what we have calculated so far.

SHUTTLE COST PER FLIGHT

Mr. BOLAND. In terms of the Shuttle cost per flight, you indicated last year that you were tracking at about $9.1 million in 1971 dollars, compared with your target cost of $10.5 million. Is that estimate still holding?

Dr. FLETCHER. That estimate is right in terms of 1971 dollars. You have to equate those estimates with the impact of inflation. Do you have that, Bill?

Mr. LILLY. Mr. Chairman, the estimated Shuttle cost per flight is $10.5 million in 1971 dollars. In the dollars of the fiscal year 1976 budget, that estimate would be $13.3 million.

SHUTTLE PRIME AND SUBCONTRACTS

Mr. TALCOTT. Dr. Fletcher, on RD 1–5 of your justifications, you indicate that there are 21 subcontracts in excess of $10 million each.

Congress usually gets interested if it is only $500,000 each. Then there are 60 subcontracts valued at between $1 million and $10 million each.

Could you give the committee, for the record, a list of these contracts and subcontracts—by location, by dollar amount, by the estimated number of jobs involved and perhaps the time frame?

We are very interested in jobs now. It might help your program a lot if you could show that there are going to be some jobs involved.

Dr. FLETCHER. We can certainly do that.

[The information follows:]

The 21 major subcontracts (over $10 million) to our prime contractors on the Space Shuttle are listed on the enclosed charts (Exhibit A) along with the information requested about each subcontract. Seventy subcontracts have been identified which are in the $1 to $10 million category. They are listed in the Exhibit B charts. In a few cases, after a company had been awarded more than one subcontract at different times, the tasks were subsequently combined under one contract by the prime contractor.

The current contract column includes the current contract value plus changes negotiated but not definitized and changes authorized with firm proposals in hand but not negotiated as of February 3, 1975. The contractor employment estimates which are provided in these exhibits represent the average direct Shuttle jobs for the funding estimates identified in the current contract column and the applicable period of performance. In addition to these direct jobs, the total employment as a result of the Shuttle, when considering the secondary or multiplier effect, could be 2 to 2½ times the direct job estimates.

EXHIBIT A

SPACE SHUTTLE—SUBCONTRACTS OVER $10,000,000

Subcontractor	Item(s)	Location	Current contract (millions)	Term of current contract	Estimated average direct jobs involved per year
Honeywell	Flight control subsystem	St. Petersburg, Fla	$71.0	February 1973 to January 1978	500
IBM	Mass memory/CRT display subsystem	Owego, N.Y.	19.7	March 1973 to January 1977	175
General Dynamics	Mid fuselage	San Diego, Calif	35.1	April 1973 to September 1977	260
Fairchild	Vertical tail	Farmingdale, N.Y.	22.2	April 1973 to July 1979	125
McDonnell-Douglas	OMS pod/tank assembly	St. Louis, Mo	67.3	April 1973 to March 1979	390
Grumman	Wing	Calverton, N.Y.	35.4	May 1973 to November 1969	185
IBM	Avionics computer	Owego, N.Y.	18.4	November 1973 to January 1977	200
Lockheed	High temperature reusable surface insulation.	Sunnyvale, Calif	24.4	May 1973 to August 1977	200
Do	Low temperature reusable surface insulation.	do			
Hamilton-Standard	Atmospheric revitalization/thermal heat transport.	Windsor Locks, Conn	20.4	August 1973 to December 1976	210
Do	Water boiler	do			
LTV	Leading edge structural subsystem	Dallas, Tex	30.6	July 1973 to December 1978	195
Pratt & Whitney	Fuel cell powerplant	East Hartford, Conn	12.1	December 1973 to June 1979	80
Aeroject	OMS engines	Sacramento, Calif	20.7	February 1974 to September 1977	200
Lockheed	Structural test	Burbank, Calif	22.1	August 1974 to February 1979	170
TRW	S-band system	Redondo Beach, Calif		Under negotiation	
Honeywell	Engine controller	Minneapolis, Minn., and Clearwater, Fla	34.1	July 1972 to September 1976	280
Rohr	SRM motor case	Chula Vista, Calif	32	November 1974 to March 1979	255
Boeing [1]	747 modifications	Seattle, Wash.:			
	Phase I		4.8	April 1974 to May 1975	170
	Phase II			Under negotiation	
Sperry [1]	Multiplexer/demultiplexer	Phoenix, Ariz	8.4	March 1974 to January 1977	105
Sunstrand [1]	Auxiliary power unit	Rockford, Ill.	9.8	February 1974 to 1981	50

[1] These contracts will be over $10,000,000 when future phases are negotiated.

EXHIBIT B

SPACE SHUTTLE—SUBCONTRACTS BETWEEN $1,000,000 AND $10,000,000

Subcontractor	Item(s)	Location	Current contract (millions)	Term of current contract	Estimate average direct jobs involved per year
Corning	Windows/windshields	Corning, N.Y.	5.1	September 1973 to July 1976	60
Menasco	Main and nose landing gear and shock strut/brace assemblies.	Burbank, Calif.	3.5	November 1973 to December 1976	40
Singer-Kearfott	Inertial measurement unit	Little Falls, N.J.	8.0	December 1973 to October 1976	95
AiResearch	Air data transducer	Torrance, Calif.	3.2	do	45
Electronics Association	Analog computer and software	West Long Branch, N.J.	1.5	December 1973 to September 1974	70
Xerox	Digital computer and software	El Segundo, Calif.	1.0	December 1973 to March 1975	30
Fairchild Stratos	12-in. prevalve	Manhattan Branch, Calif.	2.3	December 1973 to October 1976	30
Boeing	Sneak circuit analysis	Houston, Tex.	3.4	January 1974 to September 1977	50
Hoffman Electronics	Tacan (navigation)	El Monte, Calif.	1.0	April 1974 to December 1975	20
Beech	Power reactant storage assembly	Boulder, Colo.	5.7	February 1974 to June 1979	4
Modular Computer Systems	Data acquisition computer and software	Ft. Lauderdale, Fla.	1.1	February 1974 to April 1975	35
Hydraulic Research and Manufacturing.	Servo actuators	Valencia, Calif.	2.2	February 1974 to November 1975	100
Parker Hannifin	17 in. disconnect	Irvine, Calif.	1.3	March 1974 to June 1979	10
Intermetrics	Avionics software	Cambridge, Mass.	2.5	July 1973 to December 1976	25
Singer-Kearfott	Multiplexer interface	Little Falls, N.J.	3.1	March 1974 to December 1976	60
Sundstrand	Rudder/speed brake	Rockford, Ill.	7.0	April 1974 to January 1976	140
Celesco Industries	Smoke/fire detection system	Costa Mesa, Calif.	1.3	April 1974 to February 1977	15
Moog, Inc.	Main engine gimbal actuator	E. Aurora, N.Y.	4.0	April 1974 to November 1976	55
Carlton Controls	Remote pulse code equipment	East Aurora, N.Y.	3.1	April 1974 to December 1978	25
AIL/Cutler-Hammer	Microwave landing system	Farmingdale, N.Y.	1.5	April 1974 to August 1976	25
Mechanical Products	Thermal circuit breakers	Jackson, Miss.	1.4	May 1974 to June 1975	45
Harris Electronics	Pulse code modulator	Melbourne, Fla.	4.7	May 1974 to December 1976	65
Northrup	Rate gyro assembly	Norwood, Mass.	1.9	May 1974 to June 1976	35
Lear Siegler	Attitude direction indicator	Grand Rapids, Mich.	2.3	May 1974 to October 1976	35
Arrowhead Products	SSME main lines	Los Alamitos, Calif.	4.4	May 1974 to October 1976	60
Westinghouse	Master timing unit	Baltimore, Md.	2.5	May 1974 to December 1976	30
Martin-Marietta	RCS tank	Denver, Colo.	3.1	August 1974 to December 1980	15
Westinghouse	Remote power controller	Lima, Ohio	2.2	May 1974 to October 1976	30
Conrac Corp	Engine interface unit	W. Caldwell, N.J.	1.6	May 1974 to February 1977	20
ELDEC	Dedicated signal conditioner	Lynnwood, Wash.	3.5	May 1974 to January 1977	45
Ametek Straza	LH_2 fill and drain assembly	El Cajon, Calif.	3.6	May 1974 to July 1976	60
Lockheed	Ejection seats	Burbank, Calif.	2.2	May 1974 to April 1978	20
Martin-Marietta	Pyro initiator	Denver, Colo.	1.5	June 1974 May 1976	25
Hydro-Aire/Crane	Branke/skid subsystem	Burbank, Calif.	1.3	June 1974 to October 1976	20
Marquardt	RCS thruster engine	Van Nuys, Calif.	9.0	June 1974 to August 1977	100
Fairchild Stratos	Fill, vent, drain, and coupling	Manhattan Beach, Calif.	1.4	November 1974 to August 1977	20

EXHIBIT B

SPACE SHUTTLE—SUBCONTRACTS BETWEEN $1,000,000 AND $10,000,000

Subcontractor	Item(s)	Location	Current contract (millions)	Term of current contract	Estimate average direct jobs involved per year
Intermetrics	Computer language	Cambridge, Mass	1.3	November 1972 to February 1974	40
Martin-Marietta	Caution and warning electrical unit	Denver, Colo	4.7	July 1974 to October 1976	70
Do	S-band quad antenna	do			
Do	S-band hemi antenna	do		Under negotiation	
Do	S-band payload antenna	do			
Fairchild Stratos	Ammonia boiler	Manhattan Beach, Calif	2.2	July 1974 to December 1977	25
Sundstrand	Actuation subsystem	Rockford, Ill	1.4	August 1974 to December 1977	15
Rosemount Inc	Air data sensor probe	Minneapolis, Minn	1.1	July 1974 to December 1976	15
AiResearch	Ground cooling GSE	Torrance, Calif		Under negotiation	
Ametek Straza	LH^2 line assembly	El Cajon, Calif		do	
Bertea	Main landing gear strut actuator	Irvine, Calif			
Do	Main landing gear hydraulics	do	1.2	August 1974 to July 1977	20
Do	Nose landing gear actuator	do			
Singer Kearfott	Data bus coupler	Little Falls, N.J	2.5	August 1974 to December 1976	40
Do	Data bus isolation	do			
Simmonds Precision	Sensor/electronics for the LOX/LH_2 system	Vergennes, Vt	1.1	August 1974 to November 1978	10
Bendix	Surface position indicator	Teterboro, N.J			
Do	Alpha mach indicator	do	3.0	August 1974 to May 1979	25
Do	Altitude indicator	do			
Westinghouse	Power static inverter	Lima, Ohio	1.4	September 1974 to December 1976	25
Ball Brothers Research	Star tracker	Boulder, Colo	2.4	September 1974 to September 1977	30
Fairchild Stratos	Regulator, helium services, redundant	Manhattan Beach, Calif	1.4	October 1974 to June 1977	20
Do	Cryogenic fluid disconnect/gas Supply disconnect.	do	1.2	November 1974 to August 1977	20
Consolidated Controls	Shutoff valve	El Segundo, Calif	1.6	October 1974 to October 1975	55
Wright Components	2-way pneumatic solenoids	Clifton Springs, N.Y			
Do	3-way He solenoids	do	1.3	August 1974 to February 1976	30
ILC Technology	Cabin lights	Sunnyvale, Calif	1.0	August 1974 to December 1975	25
Boeing	Tail cone fairing	Seattle, Wash		Under negotiation	
Do	MAF maintenance	New Orleans, La		April 1974 to December 1975	
Do	ET dome and weld tooling	Seattle, Wash	2.3	June 1974 to June 1975	65
Hydraulic Research	Main engine hydraulic actuators	Los Angeles, Calif	5.7	July 1972 to September 1976	50
Span Master	Modernization of crane and hoist system MAF (ET)	New Orleans, La	1.1	October 1974 to November 1975	35
Binnings Construction	Pneumatic test facility (ET)	do	1.0	February 1975 to December 1975	45
Ametek Straza	Main engine flex joints	El Cajon, Calif	1.2	June 1973 to March 1976	15

SHUTTLE CARRIER AIRCRAFT

Mr. TALCOTT. Last Friday the committee was notified that NASA completed reevaluation of the selection of the Space Shuttle 747 carrier aircraft.

We were told that you selected the 747 over the C–5A. Can you tell us why it was selected over the C–5A?

Dr. FLETCHER. Yes. The decision was not too difficult because we save money by transporting the Shuttle by means of an aircraft instead of putting engines on it and flying it for testing and ferrying. We studied and assessed the alternatives very thoroughly. Although both the C–5A and the 747 could do the job the 747 system was safer. The separation phase is critical. The orbiter goes on top of the aircraft and during separation the aircraft puts its airbrakes on, dives away, and then the orbiter approach and landing characteristics are tested.

It is a critical period when the carrier aircraft and the Shuttle are separating. The separation was more difficult with the C–5A than with the 747.

Mr. TALCOTT. It looks like you might have some real problems separating the two.

Dr. FLETCHER. With the C–5A, the separation is a more critical maneuver.

Mr. YARDLEY. The C–5A also has the horizontal stabilizer of the vertical tail on top.

Dr. FLETCHER. It turned out to be a trickier problem on the C–5A than on the 747, and, in the long run, it turned out that the 747 was less expensive. It depends on how you make those calculations. Let's just say they are competitive cost-wise.

ACQUISITION OF 747 AIRCRAFT

Mr. TALCOTT. Have you acquired the 747? I don't see it in your budget. It is a pretty expensive item.

Mr. YARDLEY. We acquired it with fiscal year 1974 funds.

Mr. TALCOTT. Is it rigged out now?

Mr. YARDLEY. It is not yet modified. It is purchased and is at the Flight Research Center.

Dr. LOW. It is being used for research.

Mr. TALCOTT. You are going to use it for a number of experiments with the piggyback situation. Then I suppose you will sell it?

Dr. LOW. No, sir. It is presently being used for aeronautical safety research on minimizing the large wake vortices behind heavy airplanes. It will then be modified and used first for the approach and landing tests of the orbiter. Following that, it will be used as a ferry aircraft to carry the orbiters across the country as they are needed on west coast or east coast.

Mr. TALCOTT. So you get a pretty good airplane out of your research and development budget for your maintenance and operation.

Dr. LOW. It is serving many purposes, yes.

NATIONAL SPACE ASSOCIATION

Mr. TALCOTT. I guess that is good.

I had one general question I wanted to ask.

There is a Navy League and the Air Force Association. Now you have the National Space Association group that Dr. von Braun is heading up. Can you tell us what his relationship and his organization's relationship is to you?

Dr. FLETCHER. We are not close to that organization, Mr. Talcott, but as I understand it, it is called the National Space Association. It is an outgrowth of a private local group here called the National Space Club—here in Washington. It is their attempt to expand this local activity on a national basis. I think Dr. von Braun, who used to be with NASA and retired from NASA is going to be the head of the group. I think he is in the process of putting together a staff and actually getting subscribers. It is a private group, not a NASA group.

Mr. TALCOTT. It is completely disassociated with you?

Dr. FLETCHER. It is completely separate from NASA.

Mr. TALCOTT. You are not funding any part of it?

Dr. FLETCHER. We are not funding any part of it.

Mr. TALCOTT. You have no objection to anybody who believes in the same thing as you believe?

I am trying to find out what your relationship is, helpful, supportive, without money?

Dr. FLETCHER. If you are asking for my personal reaction, I think that this type of private association is a fine thing. A lot of people in the country are interested in space and are anxious to help with it, not necessarily aviation people, but people generally. These people want to be kept up to date. A large volume of my mail comes from people inquiring about the space program. I think this type of group can serve a useful purpose. That is my opinion, and not necessarily NASA's.

Mr. TALCOTT. They are not going around the country raising funds for your program that we don't supply, or anything of that sort?

Dr. FLETCHER. Certainly nothing that I know of, Mr. Talcott.

Mr. TALCOTT. Is it comparable to the Navy League for the Navy and to the Air Force Association for the Air Force, sort of some alumni and friends of the organization that are promotional and informational?

Dr. FLETCHER. I cannot give you very many more details. I was under the impression that it was going to be different from those other organizations in the sense that it is not going to be so much promotional but rather educational. Again, it would be better to talk to the people directly involved in the group.

Mr. TALCOTT. We do not have any way to call them before us.

Dr. FLETCHER. I can only give you impressions. I believe they have more emphasis on educational activity rather than promotional. But it is at a very early stage.

Mr. SHIPLEY. Mr. Young.

ORBITER APPROACH AND LANDING TESTS

Mr. YOUNG. Mr. Chairman, thank you very much. Dr. Fletcher, on the subject of the orbiter approach and landing tests, with the orbiter carried up on a 747, have you flown that separation in a wind tunnel?

Dr. FLETCHER. Yes.

Mr. YOUNG. With the 747?

Dr. LOW. With the 747 and with a C–5. It turned out that the 747 separation was safer and cleaner than with the C–5.

Mr. YOUNG. What degree of safety or danger is involved? That looks like a pretty close relationship there. I understand the Shuttle will have no self-contained power. It is just up there and will glide down. So he has no power to assist in the separation.

Dr. LOW. All of the tests have indicated that the separation is clean and safe.

ADVANTAGE OF 747 CARRIER AIRCRAFT

Mr. YOUNG. I was concerned about that because I noticed how close they are going to be together.

Mr. YARDLEY. Let me make a comment. You see the fairing on the back end of the Orbiter which makes it closer to the tail. That will not be on the separation test. However, it would have had to be on the C–5 for control purposes. It also reduces drag and buffeting.

Mr. YOUNG. At the speed at which you will accomplish separation, will the Orbiter maintain an altitude or will it immediately begin to descend?

Dr. FLETCHER. Initially, I believe the Orbiter is arranged to have a little bit of lift so that it maintains altitude whereas the 747 will put on spoilers and lower its altitude. So the Orbiter is flying higher and the 747 is descending. It is about a "1–G" separation, a sharp and rapid one.

Mr. YOUNG. Since you convinced me of the safety of the separation, I want to know if Mr. Talcott and I can go.

Mr. SHIPLEY. Any other questions, Mr. Young?

Mr. YOUNG. No, thank you.

SPACE FLIGHT OPERATIONS

Mr. SHIPLEY. We will turn to the space flight operations program. We note that the programs under development, test, and missions operations and space life sciences appear to be continuing at about the same level with no special problems.

SPACELAB/CONCEPT VERIFICATION TESTING

However, on page RD 2–17 under mission systems and integration, one or two questions arise. You are carrying a line item for Spacelab concept verification testing. The funding for the Spacelab development is being picked up by the Europeans in this case. I note that beginning in fiscal year 1974 and through the transition period, NASA will have spent $12,500,000. What is the total amount that NASA will be putting into this work?

Mr. YARDLEY. Let me comment on that.

Mr. SHIPLEY. Also comment on the European contribution and why they are not contributing these dollars.

Mr. YARDLEY. In terms of the respective roles, between ourselves and the Europeans, the Europeans have the responsibility for the development of the flight Spacelab and the ground support equipment for that. They do not have the responsibility for certain interface equipment, such as the tunnel between the Orbiter and the Spacelab. That is our responsibility.

There are certain interface items that we provide such as checkout simulators, so that they can test their Spacelab while they are

building it as though there were an orbiter there. The interfaces between the two must be provided for.

In addition, we have the full operational responsibility. We have to develop the techniques and capabilities for the software between flights, for the mission control, for all of the activities at Kennedy, et cetera. So there will be expenses involved on our part.

In addition, as Dr. Fletcher mentioned earlier, we will buy one Spacelab and perhaps more. Our present baseline shows that we would buy two and other more sensitive ground support equipment than what they give us, as well as other related items. So some of the money is for that purpose. The other main requirements are for concept verification testing, which is a laboratory at the Marshall Space Flight Center, where we use ground simulators to test experiments against the Spacelab concept. We put experiments in there. We have had people live in there every day for 5 days to see how they can work together, how one experiment interferes with the other, et cetera. So that is part of the $6.1 million requested for fiscal year 1976.

Mr. SHIPLEY. What have been your major problems in working together for that period of time.

Mr. YARDLEY. It has been going pretty well. We have identified what you might call minor problems that we had not thought of before where when one person is working the furnace the effect on the power supply causes somebody else's experiment to malfunction. This helps us to develop what kinds of requirements the Europeans must design into their electrical power system.

Mr. SHIPLEY. Mr. Traxler.

REASONS FOR EUROPEAN DEVELOPMENT OF SPACELAB

Mr. TRAXLER. Why are we involving Europeans in the Spacelab project if it has industrial capabilities? If it is going to produce needed products, why do we need to share these products with the European industries?

Dr. FLETCHER. Mr. Traxler, they are paying for the development of the laboratory itself, not the individual experiments that go into the lab. As a matter of fact, the lab will be available, even though they pay for it, to anyone who wants to pay the cost of using the laboratory. For example, they will pay us for the use of the laboratory. The particular experiments that go into it, the ones I described—the new alloys, the new crystals, or new biological materials—will be developed by the countries themselves.

There will be a certain amount of competitiveness between the Europeans and ourselves. It is our responsibility to keep up to date on that.

We are doing that but we are going to have some real competition for that $1 to $2 billion a year of commercial space processing. We cannot stop that since this Spacelab will be available to all the users who are willing to pay for time and space.

USE OF SPACELAB

Mr. TRAXLER. Do you foresee the initial Spacelab being developed by the Europeans as purely experimental, or do you foresee it in production later?

Dr. FLETCHER. The development is an experimental development. If there is production downstream we will simply buy the production articles from them or we have the option of building them ourselves. They have to turn over all the drawings and specifications to us on the developmental program after we have purchased the initial one or two. So the production devices to be used commercially could very well be purchased for our own use.

Mr. TRAXLER. I understand what you are telling me. You are saying that we are going to provide them with the capability of developing products in space for mass distribution. They are going to be competitive only because we are making them competitive.

Dr. LOW. The Spacelab is, in effect, an empty factory. It is a building. It has the air-conditioning, heating and cooling and all of that. But the tools that go into the factory, for our own purposes, such as manufacturing of alloys, we will build here in the United States and install in the Spacelab here. We can fly our experiments. In that sense, if we are quick enough and advanced enough, this country can be highly competitive in manufacturing in space.

On the other hand, we do have a basic agreement that we have had over the years with Europeans and others that allows them to pay for the use of our space capability. We launch their communications satellites today if they want to pay for these launches. In the future, they can come to us and say, "We want to buy time and space in the Spacelab factory." At that time we may or may not sell it to them. We are not today making them competitive in the use of the factories. They are providing the empty factory. They are helping us by providing the empty factory.

COMMERCIAL COMPETITION

Mr. TALCOTT. You are giving them all the advantages. We are spending most of the money. We have the technique, the idea and the system. Now, you are including them in at a late stage and they can take off running to outproduce us. They might be the first to make the crystals.

Dr. LOW. They are spending $420 million that we do not have in our budget, nor do we think we could budget to build that factory.

Mr. TALCOTT. Are you saying that since the Congress is so tight with your budget, you are going to Europeans and getting seed money from them and in return for that you have to share the benefits of the program?

Dr. FLETCHER. Mr. Talcott, it is our national policy, as you know, to share the launch vehicles providing that other nations who want to use them do pay the cost. They will essentially pay for each flight. The users will pay for the flights that the Spacelab makes into orbit.

Mr. TALCOTT. None of those things are competitive to our business and industry. We provide Comsat and things to look and observe, but nothing to be competitive with us. It would be helpful to them without harming us.

You know the communication satellites and all of these things. But here we are giving them a part of the factory.

Dr. FLETCHER. Except that they will pay for the use of the factory. I want to add one thing we have not yet mentioned. We do not have

any joint programs with them for commercial work. All of the commercial devices and apparatus or tools must be developed separately. That includes commercial communications satellites and it includes the commercial space processing.

If they are to compete they are going to have to develop the processes themselves. We have a fair headstart on them through our experience in the Skylab program, which was highly successful.

Mr. TALCOTT. We had a headstart on oil drilling, too. Look where we are now.

Mr. TRAXLER. Gentlemen, I want to associate myself with Mr. Talcott. You are technicians. I am, too. I am a social technician, not a scientific one. My world is the one of real people, and they are presently under great hardship with 27 percent unemployment in the automobile industry. The prospects in my State are of thousands and thousands of people who are going to be permanently out of work. I think if they were sitting on this side of the table discussing this rather esoteric problem about sharing space with other nations. I think they would have some pretty fine four-letter words in response to what you said. They are visceral people who are concerned about their mortgage payments and children. To have you tell us we have these understandings and commitments—and it is nice to put them on this equal level, they are paying for part of that lab, would not sit well. Remember, whether we like it or not, we live in a competitive society.

I don't like what you are telling me. I think we can use the technological advantage to our advantage—we have a monopoly on it.

I fail to appreciate your perfect willingness to share the opportunity for the development of these products with other countries. Think about it for a moment, would they do it for us?

Dr. FLETCHER. They are paying for the cost of the Spacelab development and providing us with a Spacelab.

The question is, are they doing enough of it?

SPACELAB FUNDING

Mr. TRAXLER. Did you ever come to this committee and request funds for something like the Spacelab?

Dr. FLETCHER. We never approached this committee for approval to develop a Spacelab. It was volunteered by the Europeans, and we agreed to let them do it.

EVOLUTION OF SPACELAB

Mr. BOLAND. Did you ever go to OMB on it?

Mr. SHAPLEY. Several years ago, as you recall, Mr. Chairman, the Space Task Force Group report was published. The Space Task Force Group report came out in September 1969, a few months after the first Apollo manned lunar landing was accomplished.

The basic recommendation out of that report, which was provided to the committee, was that NASA should simultaneously develop the Space Shuttle and what was called the Space Station. This was before the idea of the Spacelab was conceived.

In view of the budget constraints, it was decided that simultaneous development of a Space Shuttle system and a Space Station was just more than the U.S. Government could afford at that time. It was just

too costly to develop them both at the same time. So the Space Station was deferred indefinitely. We have, of course, proceeded with the Space Shuttle development. The Spacelab concept arose as a scaled-down version of the Space Station.

Dr. Low. We did not request funds from the Congress for the Spacelab. We did, at every step of the way, keep the Congress informed of the negotiations with the Europeans which led to their commitment to building and funding the Spacelab. It was not a unilateral decision on the administration's part to go forward in that direction. I think Mr. Traxler's words are very well put, and his points are very well taken. We do have a concern, particularly in the areas that do ultimately give economic advantage, of where we cooperate and where we compete.

A reimbursement policy for the Space Transportation System has not yet been decided. We are in the process of examining all the complex facets of this subject. We are analyzing all the implications very carefully, and will, of course, keep the committee fully informed on it. I think this addresses your main point.

Mr. TRAXLER. Well taken.

Mr. TALCOTT. I think the points are well taken here. I think we have to remember that through a number of administrations and Congresses and public outpourings, the people in our country have tried to importune all of us with the idea of developing better relationships with other countries in the world, including the Communist countries—to experiment with them, do social programs with them—through a vast array of different kinds of programs.

If you people did not get the message that we in the Congress and the public wanted you to cooperate and work within social programs, where Mr. Traxler is a technician, to do scientific programs and military assistance. In all of these things, we have been trying desperately to build better relationships, some of them cooperative and some competitive, to the point where we have been almost charitable. So I think you had plenty of reasons for doing what you have.

You certainly have done it openly with the consent and I think importuning of the Congress. Now, it may come as a shock to you that when we have a recession that attitudes in different Congresses may change and you have to respond to them. But I think in the past that you have been almost directed, and all other agencies in the Government have been directed, to develop better relationships with all peoples in the world.

Dr. FLETCHER. I think we have good relationships in the science area, and I think the point is well taken that we have to be very cautious in the commercial area.

Mr. TRAXLER. Especially when you are entering into preliminary understandings.

SHUTTLE EXTERNAL TANK

Mr. YOUNG. While we are on this subject of a cooperative venture in the space laboratory, why haven't you developed a way to use that expendable fuel tank in building that space laboratory?

Dr. FLETCHER. That is an awfully good point.

I do not want to say that it cannot be done. I think it is something we will have to look at.

One of the problems, as you know, with remodeling a house, quite

often the remodeling costs more than the house to begin with. Why don't we take a look at that possibility and see what can be done?

NATURE OF NASA BUDGET CONSTRAINTS

Mr. BOLAND. There are a number of people, of course, who would like to see the NASA program cut very deeply. You might find the impact of this with the new Budget Committee. You know, it is easy for the Congress to cut this particular program because these funds are relatively controllable. Uncontrollables in the Federal budget run about 75 percent of the budget. We do not really have much leeway in reducing those budget requests. But NASA is one of the relatively controllable categories. If we can get some cooperation and somebody else paying the bill, I am perfectly willing to have it done.

Maybe this is an effort to reduce NASA's cost visibility. It is a matter which was discussed with the authorizing committee?

I do not know what the authorizing committees are doing with the budget request that you present. I do not think you will be hurt very much by their actions.

Have you heard?

Dr. FLETCHER. We have not heard.

Mr. BOLAND. I do not imagine the program will be hurt too much. It is rather difficult when you get a budget that is as constrained and as tight as this one is to cut some of these programs without causing considerable harm to them.

We will do the best we can, anyway.

INTERIM UPPER STAGE/SPACE TUG

On RD 2–26, you discuss the Interim Tug and the full capability Space Tug. One of the undetermined aspects of the interim upper stage is whether or not it will be reusable.

Has that been determined yet?

Dr. FLETCHER. The interim upper stage probably will not be reusable, based on the present concept of the Air Force.

Mr. YARDLEY. Let me add one point. It is probably 99 percent sure that it will not be reusable, but the Air Force has studies going on right now. There are five different existing upper stages that are being studied. Each of the study contractors is required to study reusable and expendable versions.

We will have to look at the tradeoffs. It probably will come out that the interim upper stage, the IUS, will not be reusable. However, the study efforts are not yet completed.

TRADEOFFS ON EXPENDABLE VERSUS REUSABLE IUS

Mr. BOLAND. What are the cost tradeoffs between the expendable and the reusable?

Mr. YARDLEY. Of course, if you want the reusable version, you have to have a big enough and an efficient enough stage to deliver the propulsive energy to get from lower orbit up—which is about 14,000 feet per second. It also has to do that coming down; in other words, braking. So it has to be a much more capable stage, roughly twice. From the preliminary study results I have seen, it looks as though the

development cost of the reusable one would be at least double the cost of the expendable one.

KICK STAGES

Mr. BOLAND. I notice that the justifications suggest that for "Some outer planetary missions, additional propulsion units"—called auxiliary or kick stages—"may be necessary."

Undoubtedly, this will not be an Air Force requirement. Who will pay for these kick stages?

Mr. YARDLEY. NASA is planning to go ahead and develop and procure those.

Mr. BOLAND. How much?

Mr. YARDLEY. We cannot really estimate the cost yet because we have to know which IUS is chosen first. It is not going to be more than half of the expendable IUS cost. It would be on the order of $10 to $20 million, but not in the fiscal year 1976 budget.

APOLLO-SOYUZ TEST PROJECT

Mr. BOLAND. The justification discusses the joint U.S.-U.S.S.R. Apollo-Soyuz test project. When this flight first surfaced, one of its primary justifications was development of a universal rendezvous and docking system. This will be the last manned space flight using Apollo-type hardware. Is that true?

Dr. FLETCHER. Yes; it is the last scheduled flight using Apollo hardware.

SPACE RESCUE CAPABILITY

Mr. BOLAND. Can the Soyuz be used to effect a Shuttle rescue? Is it even technically possible?

Dr. FLETCHER. Yes; it is possible. Basically what we are developing in the Apollo-Soyuz test project is a docking system that attaches to the Apollo spacecraft and will be compatible with future Soviet docking systems. The answer to your question is that the Soyuz could dock with the Shuttle and a rescue could be performed.

Do you want to add to that, John?

Mr. YARDLEY. That is essentially right. Of course, we do not know what the Russians are going to be flying in the 1980's. The Soyuz is probably not what they are going to be using in that future period. The primary purpose of ASTP is to develop a compatible system that we could use later.

APPOLLO-SOYUZ TEST PROJECT SAFETY

Mr. BOLAND. There have been a good number of negative articles in the press about the ASTP flight. All mention the fact that the Soyuz is a very primitive vehicle, barely man rated, that has serious safety implications. Is that true about the Soyuz vehicle?

Mr. YARDLEY. No. We have looked into the safety aspects very carefully. Ever since the beginning of our relationship with the Soviets, we have had joint working groups investigating the safety during the docking phases. These joint groups have put out joint safety assessments signed by ourselves and by the Soviets. Our people have been through the Soviet's systems in depth with our own analysis. Our peo-

ple are pretty happy with them. I know of no open issues on the safety.

As a matter of fact, we just sent a safety report to the Congress. In addition, we are going to have a joint flight readiness review with the Soviets in May over in Russia and we will have our own flight readiness review, prior to the flight, down at the Cape in late June.

In summary, we think it is good. The astronauts are happy with it. They have been very interested in making sure the workmanship and quality is first class.

Mr. TALCOTT. Your friend Jack Schmitt may not agree with you.

Dr. SCHMITT. I'm happy. I got a kick out of Mr. Yardley saying that the astronauts' "happiness" was a criterion.

Mr. YARDLEY. I meant they are the last ones you make happy. It has to be good to make them happy.

Mr. BOLAND. That is probably true.

RECIPROCAL OPENNESS IN ASTP

Mr. YOUNG. I wonder if the Russians are as open with us as we are with them in preparation for the flight. Are they going to allow us to observe their liftoff and all the preparatory work being done, as we are allowing them?

Mr. YARDLEY. I would say the reciprocal openness is good. I do not believe they invited us to the actual launch and we have never indicated to the Soviets for our specialists to be there during the Soyuz launch. A limited number of selected people have been invited to visit the launch sites. We have carried out a considerable amount of joint training at their training sites and at ours. They have responded to everything we have asked them questions on.

For example, in terms of the Soyuz-11 accident in which the cosmonaut crew was killed, they gave us complete technical and medical reports. So we have no reason to believe they are not being open with us.

Mr. YOUNG. Will they have a team at the Cape to observe our launch?

Mr. YARDLEY. I doubt if they will. We would not exclude them, but they have never come before. They figure if they come to ours, they will have to let us come to theirs.

Mr. YOUNG. Is it your feeling they do not want us to come to theirs?

Dr. LOW. That is not clear, Mr. Young. We will visit their launchsite in May. I intend to be there myself at that time.

There have been indications in at least one meeting I had in the Soviet Union over a year ago that if our technicians who will have to be at the launchsite prior to the launch to set out certain equipment, wan to stay for the launch, they can, but that invitation has not been formally tendered.

We have insisted on openness on their part where we feel it is necessary to do so, the checkout of the joint hardware, understanding of their hardware systems, inspection of their spacecraft, which our astronauts will occupy. On all of those things they have been very open with us. They have let us see and touch and understand those parts which are involved in the joint mission. The launch operations as such are not involved in the joint mission. The landing is not.

We will only be together while we are in space. We have not insisted for technical reasons that it is essential for us to be there so I cannot firmly answer your question.

QUALITY OF SOYUZ SPACECRAFT

Mr. BOLAND. Are you impressed by the vehicle that you have seen?

Dr. LOW. It is a vehicle that is well designed for Earth orbital flight. We tend to compare it with our Apollo spacecraft because that is the one we used for lunar missions and we are using an Apollo spacecraft in this mission.

Our Apollo spacecraft is more sophisticated than our Gemini Earth orbital spacecraft and their Soyuz. For an Earth orbital vericle, the Soyuz appears to be well designed. Although they have had two or three mishaps over the history of this flight vehicle, since 1967, their basic record has been good, particularly in those phases of the flight where we will be together. It appears to be a well designed, safe vehicle.

SOVIET SPACE PROGRAM

Mr. TALCOTT. Mr. Chairman, the Washington Star had a report recently saying that your technical director for the program said the Russians will spend at least as much as the United States on ASTP, and that surprises me, and also that they would be at least as active as we are in space in the 1980's. Do you feel that could be true?

Dr. FLETCHER. I think that is an understatement. As far as the Apollo-Soyuz test project is concerned, they have already had, as practice for that mission, two unmanned flights plus a manned Soyuz flight.

In addition to that, they plan to count-down two Soyuz spacecraft and launch vehicles. We will be counting-down one Apollo spacecraft and its launch vehicle. We are developing the docking module, and that is our contribution. So I would say that they are putting a lot more into the project than we are.

As far as the general picture is concerned, it is pretty clear that the U.S.S.R. launches two or three times as many satellites per year as the United States does.

Dr. LOW. Last year the Soviets launched a total of 95 spacecraft with 81 launches compared to 25 U.S. launches.

Dr. FLETCHER. Their investment in space in absolute dollars is much greater than ours. In terms of their percentage of gross product, it is a major effort on their part.

SOVIET SPACE PROGRAM EXPENDITURES

Mr. YOUNG. What is the ratio of Russian expenditure for scientific research versus military application?

Dr. FLETCHER. We do not have a detailed knowledge of their military Space program. We can only guess at it. We do not have detailed knowledge of their civilian space program. It is all kind of the same

package. I would rather supply it for the record. If you want an off-hand guess, I would say their military effort is at least as great an expenditure as their civilian. Both are probably larger than we spend.

[The information follows:]

Because of the secrecy that generally shrouds the Soviet space program, we are not in a position to state the ratio that prevails between scientific and military payloads or between civilian and military payloads. Of the 95 payloads launched in 1974, two were lunar probes, five were meteorological satellites, seven were communications satellites, and five were manned spacecraft or stations. The remaining 76 were in the Cosmos series, a designation which the Soviets have been using since 1962 to explain many different activities in space without providing specific details. Studies published by the Library of Congress Congressional Research Service suggest that the ratio of military to civilian launches may be about 2 to 1.

SOVIET SPACE PROGRAM

Mr. YOUNG. Do we have an idea of where they have placed their payloads and what they are doing?

Dr. FLETCHER. On the civilian payloads, we do. On the military payloads, I do not.

Mr. TALCOTT. I think we ought to be very curious about this. In other areas of research they seem not to be spending as much as we are. In cancer research and other things, we are way ahead of them. I would like to know their motivation for such heavy emphasis in space?

Dr. FLETCHER. I am getting a little concerned about it myself. When they launch over three times as many spacecraft as we do, what are they doing with them all and what are they learning that we are not? I think we have to seriously consider the impact of that in terms of the relations between the two countries.

FRACTIONAL ORBITAL BOMBING SYSTEM

Mr. YOUNG. Do they have any of their FOBS flying today?

Dr. FLETCHER. Mr. Young, I wish I could answer that question. I am told by the military that there are not any, but I am afraid that is not my area of expertise. That is a military program and not civilian. I do not even know what FOBS stands for.

Mr. YOUNG. Fractional orbital bombing system.

What does our treaty say?

Dr. FLETCHER. We have a treaty which bans weapons in outer space. If they have bombs in orbit it is in violation of that treaty.

Dr. LOW. I think that is why the question was asked by Mr. Young, because the fractional orbital bombing system does not completely go into orbit. It is a suborbital system.

Mr. YOUNG. It could not be hanging up there. It would have to be shot, placed into the system and then deployed.

PHYSICS AND ASTRONOMY PROGRAMS

Mr. BOLAND. Turning to the physics and astronomy programs, the $155,800,000 requested for fiscal year 1976 is $19,485,000 above the current fiscal year 1975 estimate. Does any of the fiscal year 1976 request include money deferred in fiscal year 1975 and if so, how much?

Mr. LILLY. No, sir. The deferred funds are carried in our fiscal year 1975 plan. The fiscal year 1976 request is in addition to the amount that was deferred. We did this for the reason that in handling the budget, no money was taken out to be applied against the 1976 program. It was just a deferral of part of the fiscal year 1975 program, so it was kept in the 1975 column.

SUBORBITAL PROGRAM—SOUNDING ROCKET DISCOVERIES

Mr. BOLAND. With respect to the suborbital programs—sounding rockets, airborne research, and the balloon program have been continuing for some years at about the same level.

Can you give us a half dozen examples of major specific scientific discoveries that have resulted from the sounding rocket program over the past 5 years?

Dr. HINNERS. Yes, a number of scientific discoveries have come from the sounding rocket program.

Mr. BOLAND. Will you explain what they are?

Dr. HINNERS. Yes, sounding rockets are small, inexpensive research rockets that can take a payload from the ground to well above the atmosphere. After it goes through the upper atmosphere, it will turn over and bring that payload down, taking measurements as it comes down. We can recover it and use it again.

The sounding rocket is our method for getting vertical profiles of the Earth's atmosphere up to the satellite altitude. Satellites can now go down as low as 130 kilometers. Last year we had a large sounding rocket program. Over 40 sounding rockets were launched from Wallops Island in a 24-hour period. The Atmospheric Explorer satellite dipped low into the atmosphere and made actual measurements down to 130 kilometers and "remote observations" looking down toward the surface. The sounding rockets then made the vertical profile measurements up to altitude at which the satellite was observing.

Through that kind of coordinated satellite-sounding rocket program we are able to have a good calibration and correlation on what the remote sensors in our satellite have seen. So a great advance was made in giving us the real story of what the satellites observed.

It is enabling us to put together the real life story by combining the sounding rocket observations in the upper atmosphere with the observations from satellites in orbit.

Dr. LOW. What kind of things are you looking for?

Dr. HINNERS. The main think is the interaction of the sunlight with the atmosphere, with the oxygen which creates the ozone layer and with the chemical reactions that go on to create and destroy that ozone layer. Between these two, we are starting to get a better feel for the chemistry of this very complex layer which is hard to get at. You have to use the combination of aircraft, sounding rockets and satellites.

SHUTTLE POTENTIAL FOR SOUNDING ROCKET RESEARCH

Mr. BOLAND. Will it be posible to do most of the sounding rocket research aboard the Shuttle?

Dr. HINNERS. We have a study group looking at that now. We are also using the sounding rocket program as a test bed for new experi-

ments. We are telling our experimenters to tell us how they will design and test experiments for Shuttles in the same way they now do a payload for a sounding rocket.

VALUE OF BALLOON PROGRAM

Mr. BOLAND. We have been sending balloons up for years. What are we finding out with them?

Dr. HINNERS. The balloon program has two large pieces. First, observation. The balloon program lets us get to that altitude which we cannot reach with satellites because a satellite cannot reach this low an altitude. A balloon goes up to the stratosphere region and sits there for half a day, or days at a time, and makes detailed in situ observations of what is going on in the upper atmosphere.

Sounding rockets give us the vertical profile through quick up-and-down flights and the satellites measure at orbital altitudes. The balloons sit there and make measurements, for example, over a daily cycle when the Sun is shining and not shining. They all work together in a complementary program.

SKYLAB DATA ANALYSIS

Mr. BOLAND. On page RD–4–21 on the Skylab data analysis, I notice that the amount for Skylab research in fiscal year 1976 is $4.6 million above fiscal year 1975. What is going to be the total cost of this Skylab research?

Dr. HINNERS. I can answer part of that.

This number is not representative of the total amount for this Skylab data analysis. In fiscal year 1976, the Office of Space Science picks up full funding for the Skylab data analysis associated with physics and astronomy experiments. We can supply the exact number for the record but I believe the total is about $9 million in fiscal year 1975.

[The information follows:]

The initial funding for Skylab data analysis was provided under the Office of Manned Space Flight Skylab program for fiscal year 1974 and most of fiscal year 1975. The Office of Space Science is assuming responsibility for funding Skylab data analysis beginning in the last quarter of fiscal year 1975. The total funding estimated for physics and astronomy Skylab data analysis is currently projected to be approximately $24 million.

LARGE SPACE TELESCOPE

Mr. BOLAND. We talked about the large space telescope this morning. As the budget justifications point out, this Committee reduced the fiscal year 1975 request from $6,200,000 to $3 million and specified in the report that you should look at lower cost options and the possibility of international cooperation. Last year you advised the committee that the $6.2 million requested would continue phase B studies. I notice that you now want an additional $8 million for fiscal year 1976 and the transition period, in addition to the $3 million in fiscal year 1975. That totals $11 million for large space telescope studies. That seems like a good deal of money for "studies." In fact, it is more than one-half of the entire sounding rocket program.

What do you say about this?

Dr. HINNERS. The fiscal year 1975 amount was reduced from $6.2 million to $3 million. So we had to stretch out the phase B studies. A significant portion of it is to complete those studies. We now have all the study contractors onboard. We had to extend the study contractors which had been onboard the previous year to take them through this longer study period.

I think we are responding to your instructions of last year. We are investigating several lower cost or smaller telescope alternatives with the advantage that there may be reduced technological complexity. When these studies are completed, we will have a sound basis for estimating the cost of this project.

With the telescope we were studying last year, we were pushing the limits of the Shuttle weight capability. With the telescopes we are looking at now, we are well back of that. So the weight constraint will no longer be there. We found previously when you buck up against a weight constraint, you get into cost problems by having to go through and reduce or miniaturize components. We are looking at a smaller telescope and that will have a significant effect on reducing complexity. One example is in the sunshade. The conceptual design of the large telescope had a retractable baffle system to keep out light coming in from reflected objects. Now we believe we can go to a fixed sunshade of less expense. The mirror in a smaller telescope looks as though it will be reduced in terms of technological complexity. We think we will be able to go to a heavier mirror which does away with most of the requirement for what is called "active figuring."

With the 3-meter mirror it would have required pressure pads or thermal probes to keep the mirror figured, to keep the optical properties and alinement up to specification. With the smaller mirror we can make it stiffer and do away with the technological complexity of this active figuring.

We are planning to reduce the number of experiments which might be carried on the initial space telescope mission and rely more on the revisit capability. The Shuttle will have the capability to retrieve the space telescope and bring it back sometime in the mid or late 1980's so that additional or modified experiments can be put on it.

We have been talking with European Space Research Organization representatives relative to their possible participation, in two areas, supplying scientific instruments for the telescope and the solar cell arrays.

POSSIBILITY OF SOVIET PARTICIPATION

Mr. BOLAND. Have you talked with the Russians at all with respect to this program? This appears to be a program where cooperative effort ought to be welcomed by the Russians.

Dr. HINNERS. We have not talked to them about this.

Mr. BAUCUS. Why?

Dr. FLETCHER. We reached an agreement with the Russians in 1971 which is the basic agreement for all the space cooperation we have with them now.

We have made overtures to them and they to us recently that we should continue the cooperation with them and perhaps have negotiations toward a new agreement. But we have not, in the intervening

time between 1971 and now, undertaken any major space negotiations with them for the next step in cooperation.

Generally before we do this on both sides, we spend a great deal of time in defining what it is we want to do with them and then we integrate the proposals and negotiate this with them as a package. They have not yet been ready to enter into these negotiations with us. It is just a matter of time before the next step is taken.

That does not at all rule out checking with them, perhaps when Dr. Low is over there in May. I think it might be worthwhile to discuss. We do not know what their capabilities are in airborne astronomy instruments because they have not flown as many as some of the Europeans. I think it is worth exploring.

PRACTICAL BENEFIT OF SPACE TELESCOPE

Mr. BAUCUS. What practical benefit is to be derived from the large space telescope. We find out that, sure, that is the edge of space out there. It is fun, it is intriguing and it is interesting. But I wonder what practical benefits we derive?

Dr. FLETCHER. Let me try to answer that question and I think Dr. Hinners will want to add some comments. The benefits from astronomy are generally longer term than some of the others we talked about. On the other hand, they are far-reaching in their impact. The benefit from Galileo's experiments was literally the Industrial Revolution. How can you put a value on that? We are on the edge of extremely important discoveries in astronomy.

It is starting to blossom much in the same way as in the days of Galileo and Copernicus. If you ask the two areas the astronomers are most interested in, one would be the quasars, enormous energy sources coming out of these objects, second, the nature of our universe. That is an extremely long-range effect. Is our universe expanding without end? How did it begin? Is it going to contract again? Understanding those processes will contribute to our fundamental knowledge of science. There could be brand new energy sources downstream, just as nuclear energy came out of Einstein's investigations. By the way, that was astronomy, too. The whole idea of relativity came out of astronomy.

ENERGY SOURCES

Mr. BAUCUS. But it is based on the element of chance and probability.

Can you give me a percentage probability that in 5 years, from observing quasars, we can develop a significant energy source that is going to drastically help our energy picture?

Dr. FLETCHER. I would not want to guess on 5 years. In 20 years the probability is high. It takes a long period of time to translate discoveries in astronomy into practical benefits. If you are asking me to put a probability on that, it is high, about 50 percent, that you would get returns of enormous practical benefit on Earth from the large space telescope, from expanding astronomy in the way a large space telescope would do. In 5 years I would suspect very little.

Dr. LOW. We have been working for 20 years trying to control the nuclear fusion process and to get a controlled fusion reaction. I think everybody in this country agrees that in the long run that is the only

hope we have today of solving our energy problem. Yet we do not know whether our physics will ever be good enough to control that process.

If it is not, we are in deep trouble as far as the energy supply is concerned 30, 40, or 50 years from now.

It may well be that there will be discoveries from the large space telescope and other telescopes that will allow us to leapfrog in fusion reaction. The discoveries may allow us to find some other way of harnessing the energies we need to support the people on the Earth. I cannot give you numbers or probability and I don't think anybody would.

PROBABILITY OF BENEFICIAL RETURNS FROM LST

Mr. BAUCUS. One percent or a half percent?

Dr. LOW. I would say more than that.

Mr. BAUCUS. How much more?

Dr. LOW. You are asking the type of question I ask in a technical meeting. I wish I could give you one. It is more than just my guess. I can tell you that every astronomer I have talked to has indicated that today astronomers are at the limits of the capabilities of their tools, at the limits of the capabilities of the telescopes that exist today.

Usually when one gives a scientist a tool with a capability 10 times larger than exists today, he will make a new discovery. I guess, I would give you a 50–50 chance that 5 years after the LST is in orbit, we will have the beginnings of a theory that will lead to new energy sources, which we urgently need.

Mr. BAUCUS. That statement must be based upon some feeling that you have about what those quasars are all about. Can you give me any indication of the direction or what the outside parameters might be of what we would find, assuming we go through with this, in 5 years.

Dr. LOW. I am an engineer, not a scientist. I am getting well beyond my depth. All we know today is that there is an energy source out there that has the energy of 50 trillion Suns. There is not an equation or a physical understanding today that can possibly explain that phenomenon. Until we can take a closer look at it with X-rays, and gamma rays and all sorts of eyes to send above the atmosphere, I do not think there is an answer.

Once we can see 10 times better, as the large space telescope could, I think the probability is quite high. That is why I give you my 50–50 guess that the scientists of the world will come up with new theories of astrophysics.

Dr. FLETCHER. Even though you try to put probabilities on realizing benefits, even if it is only 5 or 10 percent, we are not talking about billions or trillions of dollars, we are talking about the salvation of the world. It is worth a 10 percent chance to seize the opportunity.

LST STUDY EFFORTS

Mr. TRAXLER. That brings us to an interesting point. You are talking about diminishing the size of your telescope. You started out with a 3-meter instrument. Now you are down to something less. As a result of your cost savings will the instrument be able to do the job that you want it to do?

Dr. FLETCHER. That is precisely what these studies are designed to do. The studies will assess how small you can make the telescope without giving up most of the value. That is essentially what we are doing, consistent with the committee's wishes.

Dr. LOW. We are studying three different sizes. We are studying a 6-foot, an 8-foot and a 10-foot diameter telescope. Last year we were only talking about the 1-foot diameter. That is the 3-meter telescope.

We are comparing the costs of all three. At the same time, we are understaking scientific studies to find out what capability is lost when you come down in size. Ultimately, we have to look at the gains and losses in terms of science so that we can come forward with a recommendation to the Congress.

We are not yet at that point, because the study efforts are not completed. The funds requested will allow us to reach that point.

COST OF LARGE SPACE TELESCOPE

Mr. SHIPLEY. I would like to get back down to Earth for just a moment. Your phase B study is not completed as yet?

Dr. LOW. No, sir.

Mr. SHIPLEY. We are still talking about a project cost of various guesses or estimates. I know the initial study started out a few years back.

The first time the question was asked as to what the cost would be, of course it was unknown. This is why you needed the $6.2 million. Finally, you told the committee that it would be around $300 million. Later you said that you believed it would be somewhere between $300 million and $400 million. I know that you have made some adjustments downward, I suppose, in the program as you have discussed. Do you have any concrete figures now as to what the total costs of this program will run?

Dr. HINNERS. I am very hesitant to give an estimate, since it would not be meaningful until the study efforts are completed. I think that very preliminary estimates of cost led to some of the confusion in the past, such as Viking, which you referred to this morning. In the case of Viking, that $364 million estimate was an early planning figure. It never should have been considered or quoted as a valid baseline estimate. We need to have confidence that the estimate we come up with is the figure for which we are willing to sign a "contract" and say the job will be done for that price.

I have insisted in the LST studies that there be no possibility of a "buy-in". By a buy-in, I mean that people propose a number which they think will sell and later we can get into a problem. I am new enough on the job that I want no problems like that.

Mr. SHIPLEY. I am old enough on the job to know—and I am not speaking of NASA, but in any project of any size—that estimates invariably are low and you run into cost overruns. The end result figure is unrecognizable compared to the first estimate.

Will you know when you complete phase B what this project will cost?

Dr. HINNERS. Yes, sir.

Mr. SHIPLEY. Will you be able to come to the Committee and tell us it will cost x number of dollars?

Dr. HINNERS. Yes, I will.

INTERNATIONAL PARTICIPATION IN LST

Mr. SHIPLEY. We did encourage you, and the language was in our report, to seek out other countries to cooperate in this project. We were not speaking of contacting one or two and asking them if they would like to participate, but to work out something where they will be making a sizable contribution moneywise. Why shouldn't they make a sizable contribution to this project? I am thinking of maybe one-third or one-half of the total amount of money, regardless of what the end cost will be. I do not feel that you have done that. What have you done actually?

You said you talked to the United Kingdom. Who handled this? Who made the contacts?

Dr. FLETCHER. We have made extensive contacts. Dr. Hinners' people were involved, as well as our international affairs people. United Kingdom, French, and European Space Research Organization representatives have indicated that they wanted to participate.

I can supply you the letters for the record.

[The letters follow:]

EUROPEAN SPACE RESEARCH ORGANIZATION,
DIRECTION CENTRALE HEADQUARTERS,
Neuilly, February 14, 1975.

Mr. A. W. FRUTKIN,
Assistant Administrator for International Affairs, NASA
Washington, D.C.

DEAR MR. FRUTKIN: We very much appreciated the meeting with Mr. Hinners and his colleagues. The exchange of views enables us to go forward to our various committees and to seek their advice and instructions in relation to the organization's future scientific projects.

Perhaps I could take the opportunity to stress the interest which the LST project has provoked in Europe. It is too early to talk of specific commitments, but it is incontestable that there is enthusiasm for participation in a number of European groups. We shall no doubt be reverting to this at a later stage, by which time the U.S. intentions will presumably be somewhat clearer.

Yours sincerely,

R. GIBSON,
Acting Director General.

[The attached letter, datelined February 19, 1975, from Paris, is signed by Maurice Levy, President of the Centre National d'Etudes Spatiales, 129, Rue de l'Universite, Paris VIIe, and addressed to Dr. J. C. Fletcher, NASA Administrator.]

MR. ADMINISTRATOR: In the course of the past year, representative working groups of the French scientific community have met to determine what orientation French research in space astronomy should follow in the coming years.

The reports of these groups have very clearly underscored the exceptional importance which the putting in orbit of the large space telescope will have on the evolution of knowledge in matters of astronomy and they have demonstrated the concern of French astronomers to not be held apart from this great realization.

Bearing these things in mind, it would certainly appear desirable that France participate in the development and exploitation of the LST. This participation must naturally be entered into within the framework of cooperation between the United States and the European countries joined together in ESRO.

The arrangement of annual meetings between our two agencies, on which we agreed at the time of my recent visit to Washington, ought to allow for decision in this type of question within the perspective of long-term cooperation. That is why I am proposing that at the time of our first meeting, which will soon be held, an exchange of views on the subject of the LST be added to the subjects already on the agenda.

With highest regards,

MAURICE LEVY,
President of C.N.E.S.

SCIENCE RESEARCH COUNCIL,
STATE HOUSE, HIGH HOLBORN,
London, February 26, 1975.

Mr. A. W. FRUTKIN,
NASA, Department of Planning and Programmes,
Office of International Affairs, Washington, D.C.

LARGE SPACE TELESCOPE

DEAR ARNOLD: I thought you might like to know the current situation on the SRC's consideration of the large space telescope.

As you know, we have for several years had a considerable interest in the potentialities of the LST and in 1973 we said, at one of our periodic informal meetings with you, that we were keen to explore the possibilities of a substantial involvement in the program, for example by building a key instrument, the faint object spectrograph, an area in which we had special competence.

We have had a number of meetings with your administration since then, discussing the LST, and we are in close touch with ESRO to crystallize further the practical ways in which we might become involved in the whole exciting program; and we were represented at your LST working group meeting on December 13.

Within the SRC we have been discussing in depth the scientific potential of the LST, and see the project as a major element in a worldwide drive to enable astronomy to continue in the 1980's its extraordinary thrust of the 1970's, which added to the achievements of radio astronomy the remarkable advances in X-ray astronomy.

What has been especially significant about the last decade is the complementarity of the new and old astronomies: the achievements of the whole have been much greater than the sum of the parts could possibly have been. Now it is for optical astronomy to take a big step forward with the LST.

Incidentally, you know that the SRC is responsible for ground based as well as space based astronomy, and it may be significant that we have only a couple of months ago approved in principle a large conventional optical observatory in the Northern Hemisphere. In doing so we consciously recognised that this would complement and not compete with our interest in the LST.

Yours sincerely,

H. H. ATKINSON,
Head, Astronomy, Space and Radio Division.

OUTLOOK ON INTERNATIONAL PARTICIPATION

Mr. SHIPLEY. Have you discussed specific amounts with them?

Dr. PETRONE. We have not discussed specific amounts yet.

Mr. SHIPLEY. When you sit down with these people and talk to them, they will want figures. They are not going to say they might contribute if they do not know what the total cost will be.

Dr. PETRONE. They might contribute one total array of instruments or one total array of solar power cells.

Mr. SHIPLEY. What would that amount to dollarwise?

Dr. PETRONE. It would probably be on the order of $5 to $10 million for a solar cell array.

Mr. SHIPLEY. That would be peanuts in a program like this, wouldn't it?

Dr. FLETCHER. You have to add up a lot of peanuts to get to the one-third or one-half. It is going to have to be a large number of peanuts.

Dr. HINNERS. We have looked into that problem. The Marshall Space Flight Center looked at the system and said, "What pieces of it can we separate and let them do, which we could easily integrate back into the system."

The experiments can be costly. In this case, we are talking about experiments running on the order of $10 to $20 million each. The power system and the experiments appeared to be two areas most amenable to that type of cooperation.

Mr. SHIPLEY. What other areas?

Dr. HINNERS. This is where we run into problems on the technology transfer. The LST does use a fair amount of previously developed technology, but has some new technology in it, technology which is not available at this time to the European community. Therefore, they would not be able to work with it.

Mr. SHIPLEY. What other countries?

Dr. HINNERS. The countries in the European Space Research Organization, plus the United Kingdom, and bilateral talks with the French apart from the ESRO discussions.

POSSIBLE RANGE OF INTERNATIONAL PARTICIPATION IN LST

Mr. SHIPLEY. What would you expect the outside participation to the large space telescope by other countries to be—10 percent, 20 or 50 percent?

Dr. HINNERS. I believe it would be in the 10- to 20-percent range, rather than a third to a half. We have discussed this very point with them. It is one where there may not be large parts amenable to being done in Europe and integrating back into the system. The way some of the discussions are developing, they realize some of these problems and say, OK, this is not the only kind of cooperative project we have. One way to help balance out the relative contribution is that on other projects they put in a relatively larger money contribution than, say, we do, which indeed was the case in the Helios mission, where the West Germans paid three-quarters of the funds. We paid a quarter and we are getting the considerable benefits from the experiment payloads.

JOINT UNITED STATES-WEST GERMANY HELIOS PROJECT

Mr. SHIPLEY. Was Helios their project that we participated in?

Dr. HINNERS. It was a joint project.

Mr. SHIPLEY. Did we initiate the project?

Dr. HINNERS. I don't recall.

Mr. SHAPLEY. The Helios project was initiated by the West Germans.

Mr. SHIPLEY. We are talking about the United States participating 25 percent. Is that right?

Dr. HINNERS. Yes.

POTENTIAL COST-SHARING ON LST DEVELOPMENT

Mr. SHIPLEY. But it was at their initiation what would be wrong with other countries participating 25 percent?

Mr. SHAPLEY. Mr. Shipley, I think this will be our goal in the discussions as we proceed to explore the possibilities.

The fact that we have not yet defined exactly what this LST will be, because we have not finished the studies.

We have been talking about, means that we are not in a position yet to give our European friends a firm proposition which they can take to their financial authorities as to what they might do. So I think we have to wait and let our studies proceed some more, and then proceed with the discussions with them to see just how much they will do.

Mr. SHIPLEY. You will do that upon completion of phase B?

Dr. PETRONE. We have not yet completed the phase B studies.

Mr. SHIPLEY. When will phase B be completed?

Dr. HINNERS. These specific definition studies will terminate in April 1976, but we will have information before that to allow us to come up with a cost estimate. We must have that type of information before coming in with a proposal for a new program start.

NATIONAL PRIORITIES

Mr. SHIPLEY. It is a sizable project.

You mentioned $400 million last year. With the rate of inflation and what have you, it will not surprise me if it totals $500 or $600 million by the time it is completed. I think you have a difficult project to sell. I for one find it very difficult, as I expressed last year, to go out on another program like this.

I am not arguing the benefits that could be derived from it in the field of science for maybe 1,000 years to come. But the point is we have an economic crisis in this country today and we are looking for ways to make reductions where we can.

With the housing and urban problems we have in this country today, it just does not seem to me that this should be a priority item. I can think of many ways that the $400 or $500 million could be far better spent for the use of mankind, that mankind would feel today. I hope when you complete phase B that you enlighten this committee as soon as you can as to what the total cost would be. We need concrete information on what the participation might be from other countries in something they can plainly benefit from.

Dr. FLETCHER. Mr. Shipley, may I just say that I completely agree with your last statement. I think it would be irresponsible for us to come before you with a proposal for a new program start without having defined a cost estimate that we can stand behind and second, pin down the degree to which we can get Europe and possibly the Soviet Union to contribute. We will do this before we start any program in this area.

Mr. SHIPLEY. I appreciate that remark. I will just say for myself, unless you do come in with a lesser figure and you do come in with some signed contracts so to speak, from participating countries, I for one will do everything I can to oppose this.

Mr. TALCOTT. Generally, I like to agree with Mr. Shipley. But I would just like to say that sometimes even when we are having a recession we cannot just close all the schools. We have to educate, and we have to do some research and some testing and developing. This may be the most beneficial area we can investigate and research in. I would like to ask one other thing.

You have been asked to speculate by some of the other members of the committee. I am not too sure I want you to speculate. I think you want to search. We need to know the cost of the search and what you obtain from the search. I think instead of asking you what you can do in 5 years, we have some responsibility to ask what you can come up with in five generations. Unfortunately, too many people on our side of the table ask what can you do now and then we can report back to our constituents about what is going to happen before next November.

Somebody has to be concerned with what will happen 500 years from now or five generations from now.

What was the size of Galileo's telescope?

Dr. FLETCHER. I think it was 3 or 4 inches.

Dr. HINNERS. The picture I saw a couple of weeks ago was 3 or 4 inches.

ADVANTAGES OF SPACE TELESCOPE OVER GROUND OBSERVATORIES

Mr. TALCOTT. If we developed part of an industrial revolution from that, the benefits were pretty astounding. I have a quote from M. W. Hunter in the earlier part of this year talking about the LST. He said, "Although the twinkling effect does not seem like much when observing stars with the naked eye, in the large telescope the amount by which the image wanders vastly exceeds the size of the image itself. Thus, the total image blur size is set by the atmosphere, not by the basic resolving power of the telescope. This effect is so bad that on the clearest nights imaginable, the sort that occur once every 10 years in central California, the resolving power of a 200-inch telescope on land is only equivalent to that of a 15-inch telescope in space.

On an average seeing night at the Mount Palomar Observatory, it is equivalent to only a 4-inch telescope in space." Is that accurate?

Dr. FLETCHER. That is close, yes.

Mr. TALCOTT. Can you tell us what the significance of that is to the necessity for your large space telescope?

Dr. FLETCHER. I think providing it for the record, since we do not remember all the phrases, would be better so that we can address all the points.

[The information follows:]

The large space telescope has two significant advantages over ground-based telescopes: (1) extend the wavelength range available to a large telescope to the ultraviolet and infrared regions not accessible to ground-based telescopes, and (2) obtain up to 10 times better images in the optical region than can be obtained by any telescope operating below the Earth's atmosphere.

The better resolution is essential for the study of small details. For example, in the absence of the "twinkle" effect, we will be able to monitor changes in the atmosphere of Venus, Mars, Jupiter, and Saturn with resolutions comparable to those obtained from the Mariner and Pioneer flybys. We will be able to study the nuclei of active galaxies to learn whether these nuclei are exceedingly small,

as they would be if the energy comes from a black hole, or somewhat larger, as they would be from most other sources of energy. We will be able to search for planets around other stars, planets which would be completely hidden from the surface of the Earth, not only because of the larger images which the atmosphere produces, but also because of the scattering of the light from the bright star which completely overwhelms the light from the much fainter planet. It is this same scattering which prevents us from seeing stars in the daytime from the ground.

Less obvious, but perhaps even more important, the better images from space let us observe fainter objects. By putting the telescope above the atmosphere, we lose half of the background brightness of the night sky. The remaining light comes from the Zodiacal light (sunlight scattered by interplanetary dust) and from the light of myriads of stars and galaxies too numerous and faint to see individually. We can detect faint objects by noting how much light they add compared to this background. A ground-based image of a faint star or distant galaxy covers about 1 arc second. The LST will concentrate that same light onto an area only one one-hundredth as large. Therefore, a telescope above the atmosphere could see objects 100 times fainter than the same size telescope on the ground, even if the sky were equally bright. This greatly expands the portion of the universe which we can study and lets us tackle intriguing and important questions concerning the nature of the universe and its evolution.

PRIORITIES OF ASTRONOMY

Mr. BOLAND. I suppose we have to determine what is best. Is it a large space telescope that is going to be paid for by the cooperative effort of our Nation and some European nations or the Russians, or should we have a smaller space telescope where we cannot probe as deeply into deep space? That is a judgment that we would have to make I am sure that this committee, Mr. Shipley and all of us, want you and the Nation to get the best returns. Last year we had some comments from the scientific community with respect to the LST. Some of the scientists strongly suggested that NASA had spent a large disproportionate share of dollars on planetary astronomy, such as the Pioneer and Mariner flights, but very little on deep space astronmy to which the LST, I presume, addresses itself. I guess when you look at the dollars spent, they probably have a point; or do they? What is your reaction to that?

Dr. FLETCHER. The amount that we have spent on astronomy in the past has been small compared to the planetary expenditure. However, if you look at the expenditures in this year's budget and last year's budget, the two are comparable. We include astronomy with physics and lunar with planetary. I don't think there is much difference. I think the case is really not too well made.

I think it is true, though, that it is astronomy's turn now. We are on the verge of a great leap forward in astronomy. Because of the advent of the Space Shuttle, we can put observatories up that we were not able to before. It is time that astronomy had a higher priority. I would go that far.

Mr. BOLAND. Mr. Young.

LST POTENTIAL FOR SCIENTIFIC DISCOVERIES

Mr. YOUNG. You just said we are on the verge of a great leap forward in astronomy. Earlier we were on the verge of important discovery. I imagine that the two go together. I want to ask you, one, what do you mean by "on the verge?" Are you talking about this

year, next year, 10 years down the road—what does "on the verge of" mean?

Dr. FLETCHER. Mr. Young, one cannot predict discoveries. All we know is that there would be a new potential to look at the 99.9 percent of the universe you were not able to look at before. You don't know what the discoveries are going to be, but you do know that there will be advances in understanding and knowledge.

Mr. YOUNG. You just know you are going to have a greater capability?

Dr. FLETCHER. The space telescope will be able to look ten times farther into space than any ground-based telescope.

Mr. YOUNG. So we do not know what they are, but we know we will have the capability of learning things we had not even dreamed of before?

Dr. FLETCHER. That is correct.

Do you want to add to that, Dr. Hinners?

Dr. HINNERS. Our experience, which is all we can go on in this case, says two things I would call fact. Whenever we look in a new part of what we call the spectrum, we make new discoveries. When we looked for the first time in X-ray, we saw the pulsating X-ray stars which were completely unpredicted. Now we think we are starting to get an explanation for some of them.

When we looked at the gamma ray regions, we saw strange bursts of gamma rays from someplace, completely unexpected. Now the infrared region is opening up. We will be talking about that sometime in the future. We expect on the basis of past history to find new things. The other is strictly the volume of space available. Each time we take another step out, we see new things which did not exist because we were looking too far in. You don't see the ionosphere until you get out of the lower atmosphere. You do not see the solar wind until you get outside the Earth's magnetic field. You don't see the great spirals of mass coming off the Sun until you get above the Earth's atmosphere. Every time we go farther out, we see new things. The LST will open up, we think, 1,000 times the volume of space we have not been able to look at. I cannot conceive that we wouldn't make new discoveries, although I can't tell you specifically what they will be.

Mr. YOUNG. Thank you.

Mr. BOLAND. On that note we are going to adjourn until 10 o'clock tomorrow morning.

WEDNESDAY, MARCH 5, 1975.

Mr. ROUSH. The committee will come to order.

GAO STAFF STUDY

Dr. Fletcher, we would like to go back to the GAO staff study on the space transportation system, which was discussed here yesterday rather briefly.

You told us yesterday that the $5.2 billion cost estimate in 1971 constant dollars for research, development, and testing of the Shuttle was still holding and looked good downstream.

This GAO staff study seems to challenge that testimony. The study also addresses some other points which we should get clarified for the

record, such as the need for the interim upper stage. We had discussed that last year, as I recall. The Shuttle cost per flight was also discussed yesterday. So let's go back for just a moment and ask some of the questions which relates to some of the issues raised by the General Accounting Office. Perhaps you could begin by commenting on the GAO conclusion that the Shuttle has potential for substantial cost overruns and there is little margin for potenial developmental problems. Before you respond to that, let me quote from the study on page 4 of the U.S. General Accounting Office staff study entitled "Space Transportation System."

> In our opinion, the risk of encountering cost overruns on the Space Shuttle development program has been increased. At the time of our review, realistic internal NASA projections of expected runout costs for individual projects and related reserves were not available because NASA management limits cost estimates to predetermined annual ceilings during their budgeting process. This is partially because of an agreement between NASA and OMB for funding limitations through fiscal year 1977. At the same time, prime contractors were projecting cost increases, some known technical problems were not resolved, and NASA personnel believe inflation was eroding the buying power of the budget.

Would you care to comment?

Dr. FLETCHER. Mr. Chairman, we were given a copy of that GAO staff study. In our copy, my letter to the Comptroller General, Mr. Staats, was attached. My letter to Mr. Staats commented on that very point. I would like to quote from my letter, which says,

> The GAO staff study could be seriously misleading on the development status of the Space Shuttle and NASA's cost commitment to the Congress to develop the Space Shuttle for $5.2 billion (in 1971 dollars). NASA is managing the program to the commitment of $5.2 billion, on schedule for mid-1979 launch.
>
> We have effectively accomplished this by internal schedule adjustments and, in some cases, deletion of effort without impacting the performance or the safety of the system. This process does involve the imposition of annual cost ceilings, a sound management process which we will continue in the future.

We believe that our technique of cost management is the soundest, best way to manage a program, and we believe we are being fiscally responsible to the people of the United States in managing the program in this manner. The Space Shuttle development is progressing on schedule and within our cost commitment to the Congress.

COST MANAGEMENT TECHNIQUE

Mr. ROUSH. Do you have any idea as to why GAO would have raised this question or made this point?

Dr. FLETCHER. Yes; I do. NASA's cost management technique is a different kind of management discipline than GAO is used to. We feel that in view of the extremely tight fiscal constraints under which NASA and the rest of the Government are operating, our approach is a sound way to manage the Shuttle program. In terms of the adjustments that we had to make to live within the funding limitations, we identified the deletions and deferrals after a very thorough internal management review of the Shuttle requirements. As we mentioned yesterday, Mr. Chairman, these program adjustments do not in any way affect safety and performance and the minimal technical risk is acceptable. The deletions are not going to lead to significant cost overruns. We intend to meet all commitments.

SHUTTLE COST COMMITMENT

Mr. ROUSH. I hope you are right. I hope they are wrong. But you know there has been so much publicity on cost overruns lately that I would hate to see your agency placed in a position where your testimony in these hearings would not stand. I am sure you are very conscious of the consequences of such testimony if it should be wrong.

Dr. FLETCHER. Mr. Chairman, we are very conscious of our responsibility not to overrun on this program. I made a personal commitment that the Space Shuttle would be developed within the $5.15 billion originally estimated in 1971 dollars. I regretted that we had to increase that original estimate last year because of funding cuts which were beyond my control. The increase of $50 million, bringing the cost estimate up to $5.2 billion in 1971 dollars, was caused by the schedule delay resulting from the OMB cutback in funding availability.

In this particular case, where we had to absorb the fiscal year 1976 OMB cut of $45 million in the Shuttle program, not only I but also Dr. Low, Dr. Petrone, and Mr. Yardley, reviewed the Shuttle requirements very carefully to make sure that there was no increased risk of overruns as a result of these deletions. No one can predict the future with absolute precision, but I can say that I feel as certain about the soundness of this fiscal management as I do of any program in any other part of the Federal Government.

SUCCESS OF COST-MANAGEMENT TECHNIQUE

Dr. Low. I might add that the management techniques we are using in the Space Shuttle in managing under a cost ceiling are the same techniques that we have used in some of our most successful programs. The one that comes to mind immediately is the Mariner-Venus-Mercury project which is the science project that sent a probe out to investigate Venus and Mercury. We had a firm annual and total cost ceiling on that project. It was managed by the Jet Propulsion Laboratory and the prime contractor was the Boeing Co. We stayed within that cost ceiling. We did not exceed it. Had we not imposed tight cost constraints on the project, I am sure that it would have cost considerably more than it did. It was totally successful. It was managed to stay within costs and it did.

The same technique is being applied to the Space Shuttle, and we believe that the application of this management discipline will give us a successful Shuttle, on schedule and within the cost commitment.

VIKING EXPERIENCE

Mr. ROUSH. Dr. Low, were these techniques used on Viking?

Dr. LOW. They were not used until this last year.

Dr. FLETCHER. They were used toward the latter part of the Viking program. We did use management-to-cost techniques in certain aspects of the program, and they were successful. They were not used in the overall program in the early days of the program, but they were applied during the last year and the Viking program is under control now. Dr. Petrone, who conducted the Viking reviews last fall may want to comment on that.

Dr. PETRONE. I really think in the case of Viking, we took on a great technological challenge. We encountered significant technical problems at a time when our contractor work force was at a peak level. As a result, we had to retain a large contractor work force while the technical problems were being resolved. We were also faced with launch window constraints. So we had to make some hard decisions to manage-to-cost.

I am pleased to say that since those decisions were made, we have stayed within our cost projection. Previously, we had exceeded our estimate by about $120 million. In the last 4 years the estimated cost of the Viking project has increased by about 14 percent.

The major cause was the large technological jump being made to develop a totally automated laboratory to travel to Mars and make complex observations there as a remote station. This required an extremely complex onboard computer system. It will undoubtedly be the most complex mission we have ever flown in an automated manner.

That development took time and effort beyond the level we had anticipated.

In the case of the Shuttle, our phase B study efforts were extremely comprehensive. We conducted a very thorough definition effort to study the technical and cost factors. We do not anticipate technological hurdles of the same magnitude that we had on Viking.

Dr. LOW. If I may add one more point on Viking we did not make yesterday.

The cost increase since 1970 has been less than the impact of inflation on the cost since that time period. However, as we said yesterday, it is not a good record compared with the history of NASA's other programs, which has been quite good.

BENEFITS OF NASA-DEVELOPED TECHNOLOGY

Mr. ROUSH. I think we are all conscious of the fact that one of the great returns that has come from NASA as a side benefit has been the fact that, using NASA-developed technology, you have assisted this modern industry and this modern world of ours in their management techniques. NASA, I think, has been one of the forerunners in this regard.

Mr. TALCOTT. I certainly agree with you there. I think we should also remember that the only agency of Government that has not been accused of having overruns is GAO. Perhaps the only reason is that they are the judge.

SHUTTLE COST PER FLIGHT

Mr. ROUSH. Again referring to the GAO study, and this time quoting from page 5 under the subtitle "Cost per flight," and I quote:

> NASA's use of $10.45 million in news releases and congressional testimony as cost per flight is misleading and may create confusion outside the agency. Internally, NASA uses cost per flight to evaluate decisions concerning system trade-offs between initial investment and recurring operating costs. It is the average re-

curring costs for a stated traffic model for operating the Space Shuttle only. The confusion occurs because the $10.45 million is not the total cost of the Space Shuttle, or STS operations. It may not be the cost which will be charged to the Space Shuttle users.

Would you care to comment on this?

Dr. FLETCHER. Part of the confusion arises from the fact that we have not yet decided on a reimbursement policy for the Space Transportation System. The actual cost per flight for a given user may be considerably less than the $10.45 million in 1971 dollars. We are conducting a comprehensive study on all the considerations; it is not a simple job, it is a very complex job, because we are going to be carrying multiple payloads. For example, a shuttle flight could carry a number of payloads—one for the communications industry, one for the NOAA, one for some other domestic or foreign user.

The actual charges to the users involve very complex factors. The $10.45 million to be sure, was a target number. It is the cost to NASA for putting one Shuttle into orbit. It does not, and should not, include the cost of the payloads or certain other costs that might occur.

In my judgment, however, the cost per flight to an individual user is likely to be less than that $10.45 million estimate in 1971 dollars.

Dr. Low, do you have anything to add to that?

Dr. LOW. Only to say that the $10.45 million is a valid basis for planning the Shuttle payload mission model. The GAO report itself goes on to say, in the next paragraph, that the user charge policy for the Space Shuttle has not yet been formulated and that it is currently being developed by NASA. GAO recognizes that it is premature, and we have told them that it is premature, to formulate a policy now as to what we will charge the individual payload users in the 1980's time period. We are developing a policy.

SHUTTLE REPORTING SYSTEM

Mr. ROUSH. Does the Shuttle reporting system have the capability to identify cost charges to the major elements of the Shuttle D.D.T. & E. $5.2 billion estimate by categories?

Dr. LOW. Yes, it does.

Mr. ROUSH. Can such a breakout be provided?

Mr. LILLY. Yes, sir.

Mr. ROUSH. If you will.

[The information follows:]

Like all NASA projects, cost reporting is designed to fit the requirements of management at all levels. At the highest agency summary level, we routinely identify total Shuttle cost by the major elements: orbiter, main engine, external tank, solid rocket booster, and launch and landing.

Supporting this, we have a variety of reporting systems which routinely provide very detailed cost, schedule and performance information. This detail is provided in such a fashion that each NASA manager responsible for a specific portion of the total effort is currently informed as to progress, problems, et cetera, in his area of responsibility.

The actual costs are collected and reported in real year dollar values. The conversion of the actual costs to equivalent 1971 dollar values is computed separately by deescalating the actual costs back to the 1971 dollar base. Against the current

D.D.T. & E. commitment of $5.2 billion in 1971 dollars, the actual costs through February 1975 by major program element converted to 1971 dollars are as follows:

	1971 dollars in millions
Orbiter	$821
Main engine	211
External tank	30
Solid rocket booster	10
Launch and landing	7
Technology and related development [1]	21
Vehicle and engine definition [1]	88

[1] These are now completed program elements. The last year of funding for technology and related development was fiscal year 1973 and for vehicle and engine definition was fiscal year 1972.

Mr. ROUSH. Since much of the Shuttle's development work is being performed in-house, how does NASA's performance management system report on these tasks?

Dr. FLETCHER. The in-house tasks, Mr. Chairman?

Mr. LILLY. These are identified in the same way. There are certain tasks that are done in-house, since we have the facilities and the capability. The costs are accumulated and identified to the Shuttle element in the same way that a contractor would identify those tasks to a particular element.

Mr. Roush, I would like to go back to another point just so that we will not be misunderstood.

The statement you read previously, the accounting reports record by elements to the $5.2 billion in 1971 dollars. It is not a direct comparison since obviously we are dealing in the real year dollars, and the costs that are incurred are in real year dollars, not in 1971 dollars. So you have to convert from the budget year dollars to the 1971 dollars. In a true sense, do the records reflect by category to the $5.2 billion? They do after the current dollars are converted to the 1971 dollars. Each year we have provided the Congress with the equivalent development cost estimate in the budget year dollars.

Dr. LOW. It is reconciled.

NEED FOR INTERIM UPPER STAGE AND SPACETUG

Mr. ROUSH. Last year the committee raised the issue of the cost tradeoffs on whether the full capability tug should or should not be built. You said you felt it should be built.

Te GAO study seems to question the need for an interim tug and let me quote again, this time from page 10 of the study:

> The interim upper stage is needed because NASA funding constraints precluded parallel development of the Space Shuttle and full capability tug. This is a more costly approach because the interim upper stage will be used for only about 3½ years, from June 1980 through 1983.

Would you comment on this again?

Dr. LOW. Yes, Mr. Chairman. It is true that ultimately we would like to develop a full-capability, reusable tug. However, the development of the tug is considerably more complex than the development of the interim upper stage.

A reusable space tug that could go to a very high orbit and return to the Shuttle would cost considerably more than the interim upper stage. Because of the technical complexity of the design of the full

capability tug and the limited availability of funds, as the GAO points out, we concluded, jointly with the Department of Defense, that the proper approach was to develop the interim upper stage first, use it in the initial years of Shuttle operations, and defer the funding for development of a full capability tug.

SPACE TUG CAPABILITY

Mr. ROUSH. Now you speak of the Department of Defense. Is the NASA full capability tug being coordinated to interface with all of the Department of Defense high priority payloads, and will it be capable of carrying them?

Dr. LOW. To the best of my knowledge, yes. Mr. Yardley might elaborate on that point.

Mr. YARDLEY. The Space Tug is being coordinated to interface with DOD payloads and will be able to carry them. We are talking to the Air Force about that now. They have two payloads in their whole spectrum of payloads that are slightly longer than the planned tug concept. It is also true that they are longer than some of the interim upper stages. This question is not yet resolved, but we are working on it.

Dr. LOW. We have a joint committee called the NASA–DOD Space Transportation System Committee. It was set up by an interagency agreement between DOD and NASA and is cochaired by Mr. Yardley, the head of Manned Space Flight, and Assistant Secretary of the Air Force La Berge.

The STS Committee meets frequently, and is designed to assure that the Space Transportation System meets the requirements of both NASA and DOD. I do not know of any problem that is not being assessed and resolved in that joint committee. We are well coordinated with the DOD.

TUG FACILITIES

Mr. ROUSH. Will there be a duplication of tug launch and refurbishing facilities at the eastern and western ranges?

Mr. YARDLEY. No, there will not be. Of course, we will have to have Shuttle launch facilities at both places, but all refurbishment is planned at the Kennedy Space Center, so there is only one set of facilities for refurbishment. There will be time to take the tugs back to Kennedy for refurbishment.

DESCRIPTION AND COST OF TUG FACILITIES

Mr. ROUSH. Provide for the record a listing of the tug facilities at these two sites, including a brief description and estimated cost for each facility. Also explain why it is necessary for NASA and the Air Force to have separate mission control facilities for the Space Tug.

Mr. YARDLEY. Yes. Just to comment on the mission control operations, we are working with the Air Force now on the possibly of common usage of our Mission Control Center at the Johnson Space Center. We think that we will be able to work this common use out for the basic Shuttle, operations, certainly for the early interim upper

stage missions. But the tug operations will generally be of a security level that would not permit them to operate out of the unclassified JSC Mission Control Center.

[The information follows:]

There will not be any duplication in tug refurbishment facilities. To provide the required two site launch capabilities, it will, of course, be necessary to modify and adapt the launch facilities at both the Kennedy Space Center (KSC) (the eastern test range) and at Vandenberg Air Force Base (VAFB) (the western test range) to provide capability to support the tug. However, we will provide tug refurbishment facilities only at KSC. Stages will be shipped between KSC and VAFB as necessary to use this single refurbishment facility. The tug refurbishment facilities necessary at KSC will include tug stage refurbishment and chekout stands, engine refurbishment and checkout stands, and fuel handling facilities. Costs are not available for these facilities at this time. There will be strong interdependence between tug and interim upper stage (IUS) facilities and at this point we connot define and cost IUS facilities until an IUS configuration is selected. Following that action tug facilities can be defined and costed.

Separate mission control centers may be necessary because of DOD security requirements and the use of different communications networks. However, studies are underway to assess possible sharing of facilities and/or ground crews. This decision has not been made.

SOFTWARE FOR TUG MISSION

Mr. ROUSH. How about computer programs, how much duplication will exist between the DOD and NASA computer software programs for space tug missions?

Mr. YARDLEY. We plan to use each other's software to the extent feasible. In the case of the interim upper stage, the Air Force will develop the software and we will only modify it for our specific requirements. And the opposite will be the case with the NASA Space Tug. We will develop the basic software and the Air Force will only modify it as required for their missions.

Mr. ROUSH. What specifically are you doing to reduce duplication?

Mr. YARDLEY. Only one agency has the responsibility for the major system in any of these cases, and the other agency just modifies, as required for their specific uses.

Mr. TALCOTT. Mr. Chairman?

Mr. ROUSH. Mr. Talcott.

LARGE SPACE TELESCOPE (LST)

Mr. TALCOTT. I would like to follow through for a moment on Mr. Shipley's concerns yesterday about the LST. When this large telescope was being first suggested, the size of the mirror was to be approximately 3 meters and, because of the need to develop both the mirror and the support technology, it was going to take 6 years. That was the estimate.

But now I understand you are examining smaller mirrors. As you suggested yesterday, the smaller mirrors have some technological advantage. Of course it would allow a thicker cross section with more structural strength. You have that kind of technology now.

There is a 1.8-meter mirror which we have seen in pictures you have circulated. If you went to a smaller diameter than the 3-meter proposal,

is there any reason that the current technology could not be used and the development program could not be reduced from 6 years to something less? It would considerably reduce the cost involved and we could proceed to meet the concerns of Mr. Shipley.

Dr. FLETCHER. With your permission, Mr. Talcott, I am going to ask Dr. Hinners to answer that question directly. We would probably not be flying the large space telescope before 1982. But that approach might shorten the time between when we have to make a decision on the system which could be, say, 1978 or 1979 instead of 1977 or 1978. In that sense, it could help and very likely it would reduce the cost. I would like to call on Dr. Hinners.

Mr. TALCOTT. I do not understand the timeframe as well as we understand the cost.

Dr. FLETCHER. The cost is the driver. Dr. Hinners can expand on that.

Dr. HINNERS. The costs and the schedule do go hand in hand. Part of the large space telescope phase B activity going on now is to delineate the development schedule for the various options under study.

We think that the 1982 launch time period in our estimates would provide a reasonable time for that development. One of the uncertainties with the 3-meter telescope, as I mentioned yesterday, is the new technology involved over and above the technology required for the 2.4 or 1.8 telescope. When new technology is required, you may encounter technical difficulties with resultant schedule and cost difficulties. So again, I think it comes back to our belief that the technology for the 2.4 meter and smaller telescope is well in hand, which would give us the confidence that we can stay within the schedule and cost which we come up with and present to you as our firm proposal.

TRADEOFFS ON LST MIRROR SIZES

Mr. TALCOTT. Can you estimate for us now, or for the record, the differences in the savings that we might have, with the various mirror sizes of the telescope, the 2.4 and 1.8 meter diameters; the time frame in which you could develop them; the costs that would be involved and the reasons why you would want one over the other in spite of the time requirements and the cost requirements?

Dr. FLETCHER. Mr. Talcott, I would like to answer that question, if I may. Dr. Hinners may have some comments, too. I think we need a little more time to study those tradeoffs to see whether or not it is possible to give you an idea of the comparative savings and requirements. We are very reluctant to give you an estimate of the total cost at this time because it is something we want to stand behind. We would like to have some firm contract numbers first.

But in terms of the specific question that you asked concerning the kind of savings you might get from each of these alternatives, I would like to see if we can provide you with information for the record. Would you have any problems with that, Dr. Hinners?

Dr. HINNERS. I think we can give some early estimates of what we envision might be the savings and where the certainty of knowing the technology would help us in the long run.

[The information follows:]

As mentioned in previous testimony, the definition studies for the large space telescope (LST) are currently underway and until these are completed, the estimates of cost savings can only be preliminary. A major contribution to the estimated cost savings is the reduction of 1 year in the time required to develop the 2.4-meter telescope. Other factors which will result in lower cost include a reduction in the spacecraft weight and power requirements, the increased ability to use existing facilities, thus reducing the need for new facilities, and an overall reduction in the complexity of the spacecraft.

Some of the specific changes which will provide cost savings include the reduction of the power requirements by 40 percent (3-meter system versus 2.4-meter system). This may allow the use of a solar array that has been developed for another program. The 3-meter telescope requires a retractable stray light baffle while the 2.4-meter version can use a fixed baffle which will result in a simpler and cheaper design. A reduction in the size of the primary mirror will result in a lower weight for the total telescope. This may allow the substitution of reaction wheels for the heavier, costlier, control moment gyros with an attendant reduction in electric power requirements.

The original 3-meter telescope had a requirement for figure control of the primary mirror (to control optical shape); however, by reducing the size to 2.4 meters and using a thicker mirror, the complex figure control could be eliminated, thus reducing complexity and cost. It should also be pointed out that the optical designers are confident that a 2.4-meter primary mirror can be fabricated and figured properly. A 3-meter mirror would require additional time and funding because of the higher technology requirements. The 2.4 meter mirror can use existing facilities with some modification while the 3-meter mirror will require a substantially larger investment in new facilities.

Reductions in size, weight, and complexity also carry concomitant reductions in capability. For example, a 2.4-meter mirror reduces the light collecting area by 36 percent when compared to a 3-meter system. A further reduction to a 1.8-meter size reduces this capability by 64 percent or, stated differently, a 3-meter mirror has almost three times the light collecting area of a 1.8-meter mirror. There are several vital astronomical problems which are comparatively straight forward with the 3-meter telescope, can be done with the 2.4-meter instrument, and are impossible with a 1.8-meter telescope. These include the search for planets around nearby stars, the detection of galaxies associated with quasars—which could prove or disprove whether they are emitting enormous amounts of energy—and the study of common stars in nearby galaxies.

Astronomers use a bootstrap method to estimate distances, using well-determined distances for nearer objects to estimate distances to farther ones with increasing uncertainties. For large distances, the apparant brightnesses of the largest galaxies in clusters of galaxies are used. The LST will permit us, for the first time, to use fairly good distance measuring techniques to determine directly the brightnesses of the brightest galaxies in the nearest cluster, the Virgo cluster, thus greatly improving all greater distance estimates. This process will be comparatively easy with a 3-meter telescope, can be done with a 2.4-meter instrument, and is impossible with a 1.8-meter mirror.

Even though the definition studies are not yet completed, it should be noted that the optical telescope assembly contracts have been in effect for over 18 months whereas the support systems module contract studies were negotiated in December 1974, and have been underway for less than 3 months. However, preliminary estimates of cost savings of the 2.4-meter telescope over the 3-meter version range between $60 million and $100 million.

PURPOSE OF LST PHASE B STUDIES

Mr. TALCOTT. I may be misunderstanding Mr. Shipley, but I think those are some of the questions he is trying to get answers to. They would be helpful to all of us.

Dr. LOW. Perhaps one of the points we did not make well yesterday is that we do have several definition studies underway now. These are contracted phase B studies, which will define preliminary designs for a 1.8-, 2.4-, and 3-meter diameter large space telescope.

The main purpose of these studies is to obtain definitive answers to the cost estimates and the scientific capability. Any information that we can give you before the studies are completed would be our best estimate of what is going to come out of these studies.

Mr. TALCOTT. But any appropriations that we might make before you give us that might be inappropriate, too.

Dr. LOW. We are requesting funds in fiscal year 1976 for the continuation of these phase B studies to get the answers to your questions.

LST STUDY CONTRACTORS

Mr. BOLAND. How many contractor studies are you engaged in now?

Dr. HINNERS. There are two study contractors on what we call the optical telescope assembly and scientific instruments: Perkin Elmer and ITEK.

The other major part of the telescope is called the system support module. We have three study contractors working on that. Study contracts were signed in December 1974, with Boeing, Martin Marietta Co. and Lockheed. They are looking parametrically at these three sizes so that indeed we will know what savings are projected as we go from one size to another. Each of the three study contractors for the systems support module is now concentrating on one of the sizes: 1.8-, 2.4-, and 3-meter. Sometime in late spring we hope to have an evaluation of these three versions and then home in on the preferred option to develop the firm numbers that we use to develop the LST estimates, which we will present for your consideration.

NASA HIGHLY LABOR-INTENSIVE

Mr. TALCOTT. One other question, Mr. Chairman.

Right now the Congress is somewhat obsessed with trying to provide jobs for everybody who is unemployed in the country. We are looking at all the agencies and trying to find out which agencies can provide immediate jobs, good jobs, overnight for those who are unemployed. I am just wondering how do you characterize the use of NASA funds in the aeronautics and space field and what is their impact on employment? How do you characterize them as being labor-intensive, or not labor-intensive?

Dr. FLETCHER. Mr. Talcott, we have conducted a number of studies on this very point. The most recent one is with Chase Econometrics, Inc., which is associated with the Chase-Manhattan Bank.

It is true that 85 percent of NASA's money goes directly into paying contractor and civil service people working on our programs and activities. In fiscal year 1975, the total direct employment on NASA's programs is 125,716. Our peak employment, in fiscal year 1966, was over 400,000. So NASA is highly labor-intensive.

One reason that the studies conclude that NASA is so labor-intensive is, because the existing capability of the aerospace industry is underutilized. As a result, you do not need to make the capital investment for increasing the capital assets in that industry. They are already there. Increases in NASA's spending would not have an inflationary impact, because there is underemployment and unused plant capacity throughout the aerospace industry.

So when money is provided, you have jobs immediately.

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ECONOMIC IMPACT OF $200 MILLION ADDED TO NASA PROGRAM

Every $200 million, for example, that you add to the NASA program creates on the average of 8,000 direct jobs. Those direct jobs would, in turn, create another 10,000 to 12,000 jobs as a result of the multiplier or secondary effects. So $200 million added to NASA's programs would generate a total of 18,000 to 20,000 jobs based on the multiplier considerations.

We could do it by a particular program for you, if you are interested.

To summarize, you can indeed create almost instant jobs by putting additional money into the aerospace industry, and NASA is possibly the best, most productive way to do that.

NASA DOLLARS SPENT HERE ON EARTH

Mr. TALCOTT. That is interesting and somewhat unexpected, because some people look upon NASA as having all kinds of equipment and shooting money out into space, as though it is being wasted, almost like ammunition.

I am just telling you what the general layman's concept is of some of the space programs. I take it that you do not agree with that.

Dr. FLETCHER. No, Mr. Talcott. Because of all of the flights that go out into space, all the dollars are spent here on Earth. NASA dollars go into the economy, into jobs.

In addition to creating immediate employment, the NASA-type technology that is generated, as I indicated yesterday, will create many times that number of jobs downstream. In the years ahead, the catalyst of those 8,000 direct jobs from $200 million put into the space program would indeed create many times that number of jobs downstream. There could be 40,000 to 50,000 jobs generated by the technological advances coming out of NASA's programs.

In terms of employment in either the short range or the long range, there is probably not a better way that the Government can spend the taxpayers' money. In fact, the Chase econometric studies indicate just that point.

SEVEN DOLLARS RETURNED FOR EVERY DOLLAR INVESTED IN NASA-TYPE TECHNOLOGY

Mr. TALCOTT. I thought the figure was a $7 return for every dollar invested in NASA's type of technology.

Dr. FLETCHER. That is correct, Mr. Talcott. For every $1 that you spend, you get a $7 return.

Mr. TALCOTT. I thought you were just putting it in terms of jobs.

Dr. FLETCHER. I translated that impact into jobs, because if you spend $1 now, you create direct as well as indirect jobs right away. But downstream, you will have many times that number of people employed in technology-related industries.

IMPACT OF ADDITIONAL NASA FUNDS

Mr. BOLAND. Will the gentleman yield?

I think that Mr. Talcott raises a very interesting question. Where would you put an additional $200 million if it were provided? What

employment would it provide, and what particular programs would you put it in?

Have you been asked to look at this by anyone?

Dr. FLETCHER. No one has asked us to do that particular type of employment study this year. We have done it in other years when employment was down. Mr. Lilly will comment on a recent Department of Commerce request concerning short-term, public-works-type employment.

Mr. LILLY. The Department of Commerce did ask us, as they did all agencies, I believe, to submit a list of work that could be accomplished in a short time period. They defined this time period as work that would have an immediate employment impact but would be completed or phased out within 6 to 9 months.

By that definition, our response had to limit itself mainly to rehab and maintenance or public-works-types of activities. We submitted a list of the potential employment impact of this type of effort in three different categories, I believe.

The first category, about $5 million worth of work would be started immediately and be completed in 3 months; another $32 million of effort that would last up to 9 months, and then there was some longer range effort totaling another $20 to $30 million, as I recall.

That is the only official request that we have had for that type of information.

IMPACT OF PUBLIC WORK EFFORTS

Mr. BOLAND. Of that $67 million that you mentioned, how many people would actually be put to work? I take it that is really maintenance of existing facilities.

Mr. LILLY. Yes, Mr. Chairman, it is.

Mr. BOLAND. I would think that it would not take care of over 4,000 to 4,500 people.

Mr. LILLY. The $67 million for this type of maintenance activity would probably provide 2,400 jobs on a direct, immediate basis, as well as we can estimate it now. However, in spending about $60 million in 6 months, you would have twice that effect in terms of people on the payrolls; you would multiply that by 2 in essence.

In other words, you would have about 2,400 man-years, but if you complete it in 6 months, you would have about twice that effect in terms of people.

Dr. FLETCHER. Plus the additional jobs as a result of multiplier effect.

NASA DATA PROVIDED TO THE DEPARTMENT OF COMMERCE

Mr. BOLAND. Are there particular areas to which this money might be put to that type of use, areas where the national average rate of unemployment is now 9.2 percent?

Mr. LILLY. Yes, sir. I would be happy to provide you with a list, the information that I provided to the Department of Commerce in response to their request. These were categorized by geographical locations, identifying what the unemployment rate was in these areas.

Mr. BOLAND. How soon could you supply the committee with that?

Mr. LILLY. I could supply that this afternoon.

Mr. TALCOTT. Do the same reasoning and the same conditions that were prevalent in 1972 apply now in 1975?

Mr. LILLY. The information that I referred to was recently provided to the Department of Commerce.

Dr. FLETCHER. We provided this to the Department of Commerce to respond to their request to Federal agencies.

NEED TO REDUCE UNEMPLOYMENT

Mr. BOLAND. This comes about as a result of legislation that was passed in the last session of the Congress with reference to public works projects; $500 million was authorized for the Department of Commerce and $125 million was appropriated. A total of $1 billion was appropriated for the emergency jobs program, which included $875 million for the Department of Labor.

That $125 million was to be used for, in a sense, accelerated public works. It was the responsibility of the Department of Commerce and the Department of Labor to make that particular study, and I presume that they started to screen most of the agencies. I think that is how you were asked.

I am not sure that that makes a deep enough impact on alleviating the unemployment situation. If we have 7.5 or 8 million people unemployed at the present time, it would not make enough of a dent.

Mr. TALCOTT. Of course, NASA is just one small agency in the Federal Government.

Mr. BOLAND. That is true.

Dr. FLETCHER. The main point that was left out of all of those data was the long-range impact of an R. & D. investment on employment—the 7 to 1 effect that we discussed earlier. The Department of Commerce did not ask what the long-range impact was. Everybody is interested in just what it does now.

I do think that investing in high technology industries, such as aerospace, not only gives you an immediate benefit, but also gives you the long-range benefit. In the long run, this positive effect is going to have the major impact on productivity, which has been declining lately in this country.

IMPACT OF ADDITIONAL NASA FUNDS

Mr. BOLAND. What if there were additional funds appropriated for specific programs where engineers could be put to work? There is a surplus of engineers now. They apparently have been harmed considerably by the rate of unemployment in the Nation.

What would the impact be in that particular field if there were considerable sums put into the NASA budget this year for productive work that has to be done anyway at some time? For a particular project, can you bring the project in and complete it sooner and put a considerable number of people to work without wasting a lot of money?

Dr. FLETCHER. I would like to add that the unemployment problem involves not only engineers but also technicians and shop people, and others in the aerospace field. There is a large number of blue-collar

workers involved in the aerospace industry. In fact, that is where much of the investment would be. It is true that in the case of NASA, we could put these people to work very quickly by simply augmenting the programs that are already underway, but that we had to cut back on because of budget limitations.

IMPORTANCE OF LONG-RANGE BENEFITS

Mr. TALCOTT. I am more impressed with an impact that is made immediately and also has a long-range impact than this "make-work" approach that the Commerce Department and Labor Department are looking into. They seem to be asking the agencies to come up with some maintenance and repair work that should have been going on before, especially in your agency. I thought you organized your maintenance program a little bit better than some of the other agencies. Just looking for maintenance and repair jobs, short-term jobs, is going to have an immediate impact, but is it going to have a long-range benefit?

Mr. LILLY. I would say, Mr. Talcott, that as Mr. Boland pointed out, we were responding to the Department of Commerce request for information concerning public works jobs. I would say the same factors apply in many cases to our technical facilities. They are used to provide information and to advance the technology. Examples are our wind tunnels and our aeronautical facilities, facilities of this nature.

A good part of it is short range, I would say. I would be stretching it to say it had exactly that same kind of impact.

But there are program efforts that could be done in the immediate time period and have a greater impact over the long range. There are ongoing programs which could readily be augmented. These augmentations would provide a productive way of having an immediate positive impact on employment. In addition, these types of efforts, particularly in view of NASA's high technology nature, would have a favorable long-term economic impact. There also are certain new activities that could be started.

There is one more point I would like to make, Mr. Talcott. Few experts will ever agree on an exact number for the so-called multiplier effect, the secondary effects of direct jobs. Most economists in studies that have been done estimate a multiplier effect ranging from about 1.5 on up to 4 in the near term. A study was recently done in California by the University of California at Los Angeles on the impact of the Space Shuttle on employment in a particular county there. Their study found an immediate multiplier effect of about 2.8 for every direct job provided by the Shuttle program.

In terms of the labor intensity of NASA work, all research and development work, particularly NASA's R. & D. programs, are highly labor intensive because essentially 85 percent of every dollar that we spend goes for paying people who work on the programs. Most of our R. & D. contracts have less than 15 percent of materials involved. The remaining 85 percent is all labor costs.

The cost of materials, if you want to trace it back, also has employment impact. There are a number of areas where one could usefully put money to work in the near term. It would be more economical to buy long-lead materials in the near term.

As you recognize, there are many subcontractors and vendors that we have to depend on for items such as small components. If you have to stretch that effort over a long period of time because of budget constraints, you will have to pay more. It is much more efficient for the subcontractors and vendors to provide it all at the same time.

These are the kinds of activities that a squeeze on the near-term funding affects. In many cases, this squeeze results in more of a "diseconomy" than an economy.

In summary, NASA funds certainly do create immediate and long-range employment. Our high technology programs not only stimulate economic growth and productivity, but are also noninflationary since aerospace plant capacity is underutilized.

NEED FOR IMMEDIATE AND LONG-RANGE JOBS

Mr. TALCOTT. There appears to be an immediate need and an immediate effort to develop jobs now. It seems to me it would be more important to develop a job that has a long-range impact and a short-range impact, one that is not make-work but that is really needed.

I would think you could identify jobs that are really needed in your program. Sometime we are going to have to do it. We might as well do those kinds of jobs rather than just dream up short-term jobs.

Dr. FLETCHER. We will provide the subcommittee with that information. We will address all of these questions that the members asked. Based on your questions, I think we ought to focus on two aspects: What kind of augmentations could we make in the programs that we now have, and in the new programs that we had to stop because of funding cuts; also how we can save money in the long run by investing in these particular programs.

Mr. TALCOTT. Mr. Boland is going to make a report to the full committee on Friday.

Dr. FLETCHER. Let's make it Thursday, then.

Mr. ROUSH. Dr. Fletcher, if you could, I think the subcommittee would like to receive from you as soon as possible, within the next day or two, a list of those project areas in which you might effectively spend $200 million. Also tell us what jobs these programs would create and what you would use the funds for.

It would also be helpful if you could project that and think in terms of how you would use $1 billion in this regard.

I realize that this is short notice, but we will be acting on this jobs program bill, which is going to come very shortly to the full committee and to the House.

CHASE ECONOMETRICS STUDY

Mr. ROUSH. If there is no objection, I would like to place in the record the summary of the Chase Econometrics study, which I think would be very helpful. The summary includes a statement on inflationary impact, output impact, productivity impact, employment impact, and interindustry effects.

I would like to make that a part of the record if there is no objection.

[The information follows:]

SUMMARY OF CHASE ECONOMETRICS STUDY ON SHORT-RUN ECONOMIC IMPACT OF NASA R. & D. EXPENDITURES

I. PURPOSE

The major purpose of the first phase of the Chase Econometrics study was to evaluate the short-run (within-the-year) impact of NASA R. & D. expenditures on several critical economic indicators, namely, inflation, output (GNP), productivity, employment, and interindustry relationships.

II. METHODOLOGY

The study used two interrelated approaches to identify the short-run economic effects of NASA R. & D. expenditures, namely, (1) the 185 interindustry forecasting model developed at the University of Maryland (denoted by the acronym INFORUM) and (2) the Chase Econometrics 200 equation macroeconomic model. Both models are widely known and have excellent forecasting records.

The conclusions of the study are based upon model simulations in which $1 billion of Federal expenditure is transferred (proportionately) from other Government nondefense programs to NASA programs, keeping the size of the Federal budget constant. Transfers of smaller amounts would yield proportionately smaller quantitative effects; and transfers from NASA programs to other Government nondefense programs would yield proportional effects in the opposite direction.

III. MAJOR CONCLUSIONS

Chase found the following results:

A. Output.—A $1 billion transfer of Federal expenditures to NASA programs would increase manufacturing output in 1975 by 0.1 percent or by $153 million (measured in 1971 dollars). This "results only from a redistribution of Government spending from general Federal Government expenditures to NASA expenditures," and "* * * the effect of this shift will be stabilizing."

B. Productivity.—The redistribution of demand caused by shifting Government expenditure into NASA programs "tends to shift spending from traditionally low productivity industries to higher productivity industries, thereby increasing the aggregate productivity in the economy." Thus, "* * * NASA spending tends to be more stabilizing in a recovery period than general Government spending."

C. Employment.—The transfer of $1 billion to NASA programs would increase manufacturing employment by 20,000. Although this increase is not statistically significant (because a $1 billion transfer in a $1.4 trillion economy represents a minute change) it does indicate that there would be a positive net effect on employment.

D. Inflation.—A transfer of Federal expenditures to NASA programs is not inflationary. "Conversely, it would follow that a shift away from NASA to other Federal programs could be relatively inflationary in the present economy." Furthermore, "both goals of higher employment and lower rates of inflation are not aided and possibly hindered by a lower level of NASA expenditure."

E. Interindustry effects.—The transfer of funds from general Government programs to NASA programs would tend to reduce the demand in industries currently experiencing severe bottlenecks, despite the recession, and increase the demand in industries having idle capacity and unemployment or underemployed variable inputs (labor and material).

The effect of an increase in NASA expenditures on the primary supplying industries of NASA is very significant. For example, a $1 billion increase in NASA expenditure would increase the net output of NASA-supplying industries by $1.028 billion within 1 year. This additional increase of $28 million results from the "multiplier effect" (feedback effects in the economy) of a change in the composition (not level) of Federal spending. The multiplier effect would be even more significant, affecting more nonaerospace industries, over a longer span of time.

UNEMPLOYMENT RATE IN AEROSPACE

Mr. BOLAND. Do you have any knowledge of what the rate of unemployment is in the aerospace industry?

Dr. FLETCHER. Mr. Boland, the Bureau of Labor Statistics does publish this type of data. However, some aerospace workers have gone to work in other industries, and have displaced workers from those industries. As a result, it is hard to trace them throughout the industries.

Mr. LILLY. I believe that what are commonly referred to as aerospace industries—and this cuts across some of the Bureau of Labor Statistics' categorizations—currently has on the order of 934,000 direct employees, engineers. A few years ago I believe it was about 1.4 million, in that neighborhood.

Dr. FLETCHER. Those may have been primarily engineers, not all aerospace workers.

Mr. LILLY. That may be the case.

Dr. FLETCHER. I think it is important to realize that there is a sizable number of technicians, skilled workers in the aerospace industry, that are not included in those figures.

Mr. LILLY. May I raise one point before we proceed, Mr. Roush?

Mr. ROUSH. Certainly.

GAO CIVIL ACQUISITIONS REPORT

Mr. LILLY. I do not want to let stand the inferences that might be drawn from some GAO reports by people who do not read all the disclaimers that are in the reports. The most recent example is the GAO report on civil acquisitions. In this report, GAO stated that the baseline estimate for the Shuttle development was $5.15 billion and that the current estimate was $6.6 billion. This statement is not accurate. The $5.15 billion is not the baseline estimate in current dollars; it was, as we consistently stated, the original estimate in 1971 dollars, not in current dollars.

Yet the GAO table showed a 30-percent increase. This is not the case. The Shuttle D.D.T. & E. estimate has not gone up by a 30-percent increase.

SHUTTLE D.D.T. & E. COST ESTIMATE

NASA has, each year, fully explained that the baseline estimate is in 1971 dollars. Last year, as a result of the 6-month schedule stretchout caused by funding cuts, we testified that the $5.15 billion baseline estimate had increased by $50 million in 1971 dollars. Each year, we have provided the Congress and the GAO with the current-year-dollar estimate equivalent to the 1971-dollar estimate. For instance, the baseline estimate of $5.2 billion in 1971 dollars equals $6.350 billion in the dollars of the fiscal year 1976 budget.

The GAO report indicates that we do not provide the impact of inflation on our estimates. That statement is not true. The facts are that we provide the Congress with updated information on the impact of inflation on the baseline Shuttle D.D.T. & E. cost estimate each year. So the GAO statement is inaccurate and misleading.

Mr. ROUSH. I am glad you made the statement, Mr. Lilly.

The fact is that is the reason why the question was raised. We want the record to be full and complete with regard to your own view, because we know questions may be raised elsewhere.

Mr. LILLY. Yes, sir. Thank you.

Lunar and Planetary Exploratory Program

Mr. Roush. Let's turn to the lunar and planetary exploration program.

VIKING COST ESTIMATES

I would like to ask some questions about the Viking program, beginning on page RD 5–6. In last year's hearings on page 252, there is a table which outlines the estimated total cost of various projects. Viking is shown as $495.5 million through fiscal year 1973. Fiscal year 1974 is shown as $224.7 million .

When we look at the budget justifications, we can see what has happened since then. The fiscal year 1974 amount actually turned out to be $290.4 million. Fiscal year 1975 is shown as $89 million. But you reprogramed about $48 million of fiscal year 1974 Skylab funds to Viking. The fiscal year 1976 request is $39.5 million, plus $14 million for the transition period. Now this totals $928 million to date and that does not include the boosters which would add another $76 million.

Now how much additional will be required for this program in future years?

Dr. Petrone. The $48.8 million of Skylab savings reprogramed to Viking is included in the fiscal year 1974 amount, the $290.4 million. The fiscal year 1975 estimate is $89 million. The fiscal year 1976 budget request is $39.5 million, and the transition period request is $14 million. The balance to completion is projected as $21 million.

The total estimated cost of the Viking project is currently estimated at $930 to $950 million, excluding the launch vehicles.

FUTURE PROGRAMS

Mr. Roush. That is close to $1 billion for Viking.

Now, given the funding levels which NASA has had to contend with in the past few years, Dr. Fletcher, do you think you would be willing to start another program of this sort in future years?

Dr. Fletcher. Mr. Chairman, I think that at the present time it would not be a wise thing to start a planetary program of that type and magnitude. I think that we should see what comes from the data that we gather from the Viking landers before we contemplate another program of this nature.

However, in retrospect, I think even though we did encounter a 14-percent increase because of developmental difficulties, as Dr. Low pointed out, Viking may very well be one of the wisest investments that we have made. The potential returns are far-reaching. Of course, it depends on the outcome of the missions.

POTENTIAL SIGNIFICANCE OF VIKING

Mr. Roush. We cannot just look at the experiments that are involved in this particular program, can we, in measuring results?

Dr. Fletcher. That is correct, Mr. Chairman. There are many other considerations in addition to the experiments. Not the least of these is our preeminence in space and the far-reaching implications of the possibility of life on the planet Mars.

If indeed life is detected with the biological laboratory which will land on the planet, it could change our whole thinking about life in the solar system and how it evolved. Long-range, this type of discovery could open up possibilities for human colonization.

That is certainly far downstream. But if life is found, there would be profound philosophical and social possibilities to consider.

THEORETICAL RESEARCH ON EXTRATERRESTRIAL LIFE

Mr. ROUSH. Do you have people who are doing theoretical work which relates to extraterrestrial life?

Dr. FLETCHER. Yes, we do. Dr. Hinners may want to elaborate.

Dr. HINNERS. We have what are called planetary, exobiology efforts. These efforts involve people who do research on the theoretical aspects of extraterrestrial life.

They look at the theory of how one develops organic chemicals, starting from inorganic materials. These activities are also supported by laboratory investigations which try to duplicate the conditions which lead to this initial formation of the organic molecules. These same people take the data from our planetary programs, such as the Pioneer probes which flew past Jupiter. They look at the composition of the atmosphere and ask, "Are those conditions such that life could have, theoretically, originated in that environment?" They also specify the conditions which they think are required for life to exist, and determine the possibility of life existing in various places. Then they set some of the goals we should be looking at in our experimental program and our flight programs. In other words, they give us a basis for the design of experiments to conduct what we call the search for life.

PROBABILITY OF LIFE ON OTHER PLANETS

Mr. ROUSH. Have you come to any conclusions as to the probability of life on other planets, intelligent life on other planets?

Dr. HINNERS. In terms of a personal hypothesis?

Mr. ROUSH. Yes.

Dr. HINNERS. Yes, I have my own personal views on that probability.

Mr. ROUSH. I realize it is theoretical.

Dr. HINNERS. Yes, sir. It represents my personal hypothesis on the probability.

Mr. ROUSH. Go ahead.

Dr. HINNERS. It is a personal opinion, and I would like to present it in that way, although there are some others who share this view.

Our Sun appears to be one of the most common types of stars in the galaxy. There are approximately 100 billion stars in our little galaxy. I say little galaxy, because we think there are something like 100 billion galaxies.

Our Sun, a common star, has its planetary system. We know of no reason right now why most other stars should not also have planetary systems. Up to now we have not been able to detect whether or not even the nearest star has a planetary system.

With the large space telescope, we will have the ability to look at the nearest 30 or 40 stars to see if they do have planetary systems. We do not believe we are unique. We feel that there must be hundreds of billions of planetary systems. Just by the sheer numbers, believing that our planetary system is not unique, we feel that someplace out there in space, there must be conditions similar to those which gave rise to life on Earth.

In terms of theoretical study of our solar system, we think that conditions on Mars might be the most favorable, as well as in the atmosphere of Jupiter and possibly Saturn, to have led to the inital creation of the organic molecules which in turn lead to life processes.

Mr. ROUSH. Thank you.

I guess we had better get back to Earth.

SCIENTIFIC VIEWS ON PROBABILITY OF EXTRATERRESTRIAL LIFE

Mr. TALCOTT. There are people who differ from you, too. You sad some people agree with you.

Dr. HINNERS Yes, Mr. Talcott. I do not want to imply that there is unanimous agreement by any means. But most of the scientists that I have dealt with do come to the conclusion, without wanting to put a number on the probability, that somewhere out there other forms of intelligent life must exist. Of course, many more forms of lower life may exist. In addition, there is the possibility, that there may be life out there that is more intelligent than we are.

SAGAN THEORY

Mr. ROUSH. Most of the scientists I have discussed this subject with agree with you, but they also state that the chances of interplanetary travel or visitation from other planets revolving around other suns is simply not possible.

Dr. Sagan would hold to that view.

Dr. HINNERS. I was talking to Dr. Sagan last night.

Mr. ROUSH. He may have changed his mind, but my understanding of Dr. Sagan's theory is that he would say precisely what you said, that there are 100 billion stars out there and that theoretically there probably is life on planets around those stars, but he does not believe that we are being visited. He believes visitation is impossible because of the distance.

Dr. PETRONE. It would be impossible by any technique that we understand today.

Mr. ROUSH. I asked him that. I said you are being very dogmatic about your statement. He said, "No, I am a scientist."

Dr. FLETCHER. You are correct, Mr. Chairman, in the distinction between theoretical probability and actual possibilities in terms of today's technology and techniques.

Mr. ROUSH. I said anything a man can imagine, I think, can happen.

Dr. PETRONE. Exactly, I agree with that.

Mr. ROUSH. As you know, the probability of extraterrestrial life is a matter of interest to a lot of people. If NASA is doing research along this line, I think the people deserve to know about it.

Mr. Traxler?

LARGE SPACE TELESCOPE MIRROR

Mr. TRAXLER. Let's go back to the LST for a moment. Let's get something into the record as to the importance of that instrument and the mission you expect it to perform. We talked about some of the technological problems with a larger mirror and about some of the concerns budgetwise about it.

I think you ought to describe for us the importance, if there is an importance, of the largest possible mirror that you can put up there.

Dr. HINNERS. Yes.

Mr. TRAXLER. The lens?

Dr. HINNERS. Yes, we are studying those considerations very carefully. As I mentioned, we have contractors looking at the hardware aspect of it.

We have also been working with our space telescope science group to do exactly that. We have asked them, as best they can, to quantify the science return as a function of size. In my view, it is not worth proceeding with a large space telescope if we are not making a significant jump over our present capability. Yet we also know that it is human nature to ask for as much as you possibly can.

So we are looking into the tradeoffs on scientific returns versus technical and cost considerations.

Dr. FLETCHER. We already know that some investigations can only be done with the 3-meter mirror. We mentioned some of those, but I think it is important to mention them again.

We will be able to see about 1,000 times the volume of the heavens with this type of telescope. That is 10 times farther out. We will also be able to see planets, if there are any, on 30 to 40 near stars, which is an important contribution.

We also will be able to observe a much larger number of quasars, these strange new energy sources. But they seem to be way out, long distances from the Earth. By observing more of them, we may be able to understand some of the basic energy processes which could eventually have benefits here on Earth.

We will also be able to observe, in considerable detail, our own planets and observe them over a long period of time. The best we can do now in terms of the distant planets is to investigate them using automated, unmanned spacecraft which fly by the planets. But to actually see the detailed changes in weather patterns, on Jupiter for example, and how they might impact or influence our ideas about our own weather patterns, we would need a large space telescope with a 3-meter-diameter mirror.

As Dr. Hinners stated, we are studying the tradeoffs on various mirror sizes. We are, for instance, studying whether or not a 2.4-meter-diameter mirror or possibly a 1.8-meter-diameter mirror would provide this capability. Those comparative studies are underway. However, the advantages of having a 3-meter-diameter mirror are clear and have been well stated by the scientific community.

ESTIMATED COST OF SPACE SCIENCE PROJECTS

Mr. ROUSH. On page RD 5–9, the funding for the Mariner-Jupiter-Saturn 1977 mission is shown. Last year you indicated that this project

would cost a maximum of $320 million. What is the current estimate?

Also, please update the table on the estimated cost of space science projects referred to in the 1975 hearings on page 252.

[The information follows:]

ESTIMATED PROJECT COSTS

[In millions of dollars; fiscal years]

	1974 and prior	1975	1976	Transition	Estimated balance to complete	Total estimated cost
OSO-I	50.2	5.0	2.6	0.5	0-1	57-59
HEAO A, B, and C	40.1	42.9	56.6	12.0	48-68	200-220
Atmosphere explorer C-E	41.1	7.5	5.5	1.2	1-5	56-60
Small astronomy satellite	41.9	4.2	1.6	.5	2-5	50-53
Dual air density/Hawkeye explorers	8.7	1.2	.7	.1	0-1	10-12
Radio astronomy explorer	20.4	.1	.1			20-21
International Sun-Earth explorers		7.0	15.0	4.0	16-20	42-46
International ultraviolet explorer	5.6	10.0	6.5	1.6	4-9	28-33
Pioneer 10 and 11	89.2	5.3	3.9	.9	13-17	112-116
Viking	785.9	89.0	39.5	14.0	2-22	930-950
Mariner Venus-Mercury 1973	97.5	5.4			0-2	100-105
Mariner Jupiter-Saturn 1977 (OPM)	42.6	69.8	82.4	22.6	63-103	280-320
Helios	8.3	1.4	1.1	.1	0-4	11-15
Pioneer Venus		26.9	57.6	15.3	60-90	160-190

Dr. HINNERS. There is no change to our estimate of last year. The cost of the Mariner-Jupiter-Saturn project is still estimated from $280 million to $320 excluding the launch vehicle.

PIONEER VENUS

Mr. ROUSH. On page RD 5-12, is the total cost of the Pioneer-Venus project still holding at an upper limit of $190 million?

Mr. LILLY. Yes, sir, it is.

Mr. ROUSH. I note you are asking for the second year of project funding this time, $57.6 million; is that correct?

Dr. LOW. Yes, Mr. Chairman, that is correct.

LAUNCH VEHICLE PROCUREMENT

Mr. ROUSH. On page RD 6-1, launch vehicle procurement is shown. How many launch vehicles are required before the Shuttle is operational in 1980 and how many of those will be at least partly funded with the funds requested through the transition period?

Mr. LILLY. I would have to go through and add these figures up and check the inventory against that.

Mr. ROUSH. Will you supply that for the record?

Mr. LILLY. Yes, Mr. Chairman.

[The information follows:]

The NASA launch schedule lists a total of 31 launches by conventional launch vehicles in support of currently authorized NASA automated satellite missions during the 1975-80 timeframe. With one exception, the hardware procurement funding for these missions will have been at least partially funded through the transition period.

For reimbursable customers, NASA currently anticipates launching an additional 65 missions during the 1975-80 period. Included in this number are launches for other U.S. Government agencies, international and commercial users for scientific, research, communications and applications missions.

Thus, a total of about 90 launches is currently planned for conventional launch vehicles during this pre-Shuttle period. We expect that this number could increase slightly as subsequent year budgets are better defined.

FUTURE PROCUREMENT

Mr. ROUSH. I assume launch vehicle procurement under NASA should be nearly zero by 1980, is that correct?

Mr. LILLY. Except for certain small ones for projects such as Sounding Rockets, it should be phasing down, in that time period. The transition process is under study.

Dr. PETRONE. I would like to address that. We will be going through what we call a transition phase, from the expendable launch vehicles to the Shuttle.

We have to look at our customers and see what their spacecraft and mission requirements are. We have to go through the transition phase with the customer, to start designing the spacecraft for the Shuttle, and to see exactly what we do in 1980–81 period.

We have Comsat, for example, as a customer. We must guarantee the customers a time for launch. We are now in the process of developing a policy and addressing the many complex questions that are involved. As a result we cannot yet identify the specific year that the expendable launch vehicles will be terminated. We are studying the transition process. It will be in that timeframe, but the transition process will be important, whether it is 1980 or 1981 or further downstream, in terms of determining the phasedown in the expendable launch vehicle procurement.

Dr. FLETCHER. Whatever is the case, the number there will be much lower than it is now, because we are designing payloads for the Shuttle. But we do have those outside customers that Dr. Petrone mentioned, and we have to meet their requirements in the transition period.

Mr. ROUSH. If you want to elaborate, we would like to have that as part of the record.

Dr. PETRONE. Very well.

[The information follows:]

Looking to the future we see three distinct periods of space transportation. In the first period, we will continue to operate expendable launch vehicles. In 1980, we will begin the second period with the introduction of the new space transportation system including the Space Shuttle and the interim upper stage (IUS). In this period of transition, we will continue to operate expendable launch vehicles. We will be phasing out the old space transportation system and phasing in the new. In the third period, we plan that only the new space transportation system will be operational.

In the transition period, the Space Shuttle/IUS launch rate will build up at a prudent rate. The balance of the traffic not flown on the Shuttle will be launched by expendable launch vehicles. The exact mix of Shuttle and expendable launch vehicle flights and the length of this period are presently indeterminate. Now, in the midseventies, over half of our traffic is reimbursable non-NASA missions. The leadtime for procurement of our launch vehicles is on the order of 2 to 3 years; so, it will be the late seventies before these outside users state their launch requirements for the early eighties. The transition period will end when the Shuttle launch rate builds up to the point that it can handle all that traffic.

Mr. ROUSH. One other question in this regard.

The customer, the user of the Shuttle, knows that the Shuttle is on its way?

Dr. PETRONE. Yes, sir.

Mr. ROUSH. Would I not be correct in assuming that he is designing his satellites to fit that Shuttle?

Dr. PETRONE. That is part of our ongoing discussions. If a customer is making a buy, starting in 1979, of 12 spacecraft, we will consult with him. We need to know what the customer is going to buy and what we need to have available for launch services during the transition period.

We will have a period of transition from the expendables to the Shuttle. We must bring together the customers' spacecraft and mission requirements with the launch services available at that time.

Dr. FLETCHER. It would, of course, be cheaper for the customer to buy spacecraft that are exactly the same, instead of buying part for the expendables and part for the Shuttles. We have to take his economics into consideration.

SPACE APPLICATIONS PROGRAM

Mr. ROUSH. Turn to the space applications program. Let's begin on page RD 7–19 with the synchronous meteorological satellite.

EFFECT OF ATS–6 AND SMS–1 ON RADIO ASTRONOMY OBSERVATIONS

We have been informally advised by NSF that a serious problem has developed with maintaining clear radio spectrum slots for the radio telescopes at Greenbank. Apparently the principal offenders are the ATS–6 and the SMS–1.

Are you aware of this problem, and can you enlighten us?

Mr. MATHEWS. Yes. We are aware of the questions, Mr. Chairman. There is some diversity of opinion as to the seriousness of the problem. Generally speaking, there have been no serious interruptions of the observations at any of the astronomical observatories to date.

As a matter of fact, in the case of ATS–6 the knowledge of this possibility existed for several years and filters are an intrinsic part of the design of the ATS–6 spacecraft to avoid interference with an important astronomical frequency band that is in close proximity to the ATS–6 frequencies.

Now, if the ATS is pointed directly in the vicinity of one of these stations, which occurs infrequently, it can produce some interference, but we do not believe that this has caused any major problems with the observations.

COORDINATION OF FREQUENCY ALLOCATIONS

Mr. ROUSH. We had the impression that NSF was a bit more concerned and thought it was a more serious problem than apparently you are expressing here today. What is the coordination that exists between NSF and NASA in this regard, if any?

Mr. MATHEWS. Coordination does take place. There have been a number of meetings among the scientific community, NASA, and NSF. I think their concern is largely related to the possibility that for instance, if a significant number of SMS satellites were deployed, and each one had "out-of-band" transmissions, this could potentially create problems. They want to make sure that we account in our fre-

quency assignments for the fact that these problems could exist, and we are attempting to do that.

I do not think the current situation has created any major problems.

Dr. Low. Mr. Chairman, there is a committee of the National Academy of Sciences, called the Committee on Radio Frequencies. This committee is interested in this subject, and we are coordinating with them. In addition, there are other organizations involved in coordinating the resolution of any issues.

Mr. Truszynski has information on that coordination.

Mr. TRUSZYNSKI. Mr. Roush, this frequency interference question is one that is not new. What we have done, as Dr. Low and Mr. Mathews indicated, is to be sure that members of the radio astronomy community are actively engaged in all of our frequency allocation activities as a part of the normal work of the Interdepartmental Advisory Committee on Frequency Allocations.

What we have done is to be sure that in all of our future planning, we do take account of the specific frequencies that the radioastronomy community is interested in, and we will proceed to work out the frequencies on our spacecraft, including proper filtering, so that we do not overwhelm the particular frequency bands of interest to the community. This effort is carefully coordinated.

Mr. ROUSH. The committee is interested in this matter of coordination between various agencies involved and elements of the scientific community that might be involved because this is a large investment and we do not want to see that investment in any way endangered.

Thank you, Mr. Truszynski.

POLLUTION MONITORING

Now turn to page RD 7–20, the pollution monitoring programs. I notice the current fiscal year 1975 estimate is $7.4 million below your last year's estimate. Is this part of the $16 million deferred in the applications program?

Mr. LILLY. No, sir, it is not.

NIMBUS–G

Mr. ROUSH. What was deferred and what was transferred to Landsat–C?

Mr. LILLY. Mr. Chairman, $5 million was transferred to Landsat–C, and the amount deferred in Nimbus–G was $7.2 million. That $7.2 million is included in the current fiscal year 1975 estimate. It is part of the fiscal year 1975 program plan.

Mr. ROUSH. Has Nimbus–G slipped and, if so, why?

Mr. MATHEWS. Mr. Chairman, Nimbus–G has not slipped. This change is a result of a later start in the spending on this program than we had originally contemplated. It was in part involved with establishing the right contractual arrangement with the spacecraft contractor.

In addition, there have been some delays in getting some of the instruments under contract. The contract, in fact, has been let with the spacecraft contractor and with one exception, all the instrument contracts have been let.

LANDSAT–C APPROVAL

Mr. ROUSH. Thank you.

I understand that yesterday you talked about the name change of ERTS to Landsat.

I do note that Landsat–C has finally received a go-ahead. I believe that the Congress did a little prodding in this regard.

Dr. FLETCHER. That is correct, Mr. Chairman.

Mr. ROUSH. And the President gave it a little push, too.

Dr. FLETCHER. Taking all the facts into consideration, including the fact that the Congress had authorized a third Earth resources satellite and had expressed considerable support for it, the President did make the decision to have NASA go ahead with Landsat–C.

Mr. ROUSH. Who was against it and what are the pros and cons?

Dr. FLETCHER. It is a long story, Mr. Chairman. The crux of it was probably a problem in semantics. The Office of Management and Budget had the impression that NASA might be moving too rapidly to an operational Earth resources system, and that the research and development efforts should be completed first. Actually, Landsat–C is not an operational satellite, even though we are doing semioperational verification experiments on the ground with the Department of Agriculture and others. Landsat–C is an experimental satellite. Once we had resolved that issue, there was no major opposition from the Office of Management and Budget.

PROGRESS OF LANDSAT PROGRAM

Mr. ROUSH. Is the progress of this particular Landsat satellite somewhat comparable with that of NIMBUS, which had its beginning as an experimental satellite and suddenly was so good that it was really a very usable satellite?

Is Landsat somewhat comparable to that program?

Dr. FLETCHER. Mr. Chairman, I was not with NASA during the early days of the NIMBUS program, but from what I can gather, the use of the Landsat–1—the first satellite which we used to call ERTS—turned out to be even broader-based than we had visualized. Not only the experimenters involved, but State agencies and Federal agencies, as well as foreign countries, all wanted to use the data, as if it were an operational satellite.

I think we underestimated the extent of early user involvement, and it took us a little while to keep up with the demand for the data. In that sense, it probably is one of the "best used" satellites that we have ever put in orbit in terms of user involvement and enthusiasm.

Mr. MATHEWS. If I may add to that, Mr. Chairman.

As contrasted to the NIMBUS activity, which primarily supported meteorology or weather forecasting, the Landsat supports many uses in areas ranging from agriculture and hydrology to oceanography and meteorology.

I think that the Landsat program has tremendous value. The worldwide response to the information produced by Landsat highlights the fact that it is a challenge to meet the tremendous potentials that this type of satellite has.

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VALUE OF LANDSAT

Mr. ROUSH. What is the potential? You referred to what it is doing now. What is the full potential of Landsat?

Mr. MATHEWS. Mr. Chairman, let me start out by saying that I think what everyone is striving for these days is a better information base. Everyone from our President and other heads of state and on down is looking for more solid information on which to base decisions, particularly where decisions are inhibited by the lack of that information base. I am not saying that Landsat is a total answer to this need, but in critical areas such as food production, we can use Landsat data to obtain information on a global food production We can also obtain data that can be used for improved management of water supplies in reservoir systems. In addition, we can obtain information that will help in better management of rangelands.

Undoubtedly in a system sense, other types of information must be gathered to complement the Landsat information, but I think it is a very important start toward establishing a better information base on these very important matters.

INTERNATIONAL POLICY ON LANDSAT DATA

Mr. ROUSH. Will this create any problems internationally or will it be a tool whereby we can enhance our position internationally? What is your thinking in this regard? I can see where it could be a problem with us having this knowledge and other nations resenting it or feeling as though we are spying on them. I can also see how it can be used as a tool in our international relations.

Would you care to discuss that from a policy standpoint, Dr. Fletcher?

Dr. FLETCHER. I would like to discuss that, Mr. Roush. There has been and continues to be a potential problem but it has never materialized. It has been much discussed in the United Nations at the instance of a few members. But so far, we have kept a completely open program. We have agreed to sell the data at cost to all countries. We have some 50 foreign countries involved in the investigations.

For that reason, there has been no objection whatsoever to the experimental program.

Now in terms of benefits, I think the potential is enormous. An initial study on the economic benefits, just from three or four different uses of Landsat-C, identified on the order of $750 million of benefits a year from operational Landsat-C type satellite system. A large part of those benefits are in the agricultural area, but there are also significant returns in the other areas that Mr. Mathews mentioned. The initial study did address the full impact of international agricultural information on the U.S. economy. It only consists of benefits that we would gain from inventories and forecasts of our own agricultural conditions. Improved knowledge of the wheat production conditions in Canada, the Soviet Union, and all the other countries of the world will help stabilize international food prices. Ultimately, the consumer ought to benefit from the knowledge obtained about global agricultural conditions. With a steady flow of food to the grocery stores, prices should tend to stabilize.

The benefits estimated in these economic studies assume that the program being conducted with the Departments of Agriculture and Commerce, the large area crop inventory experiment, is successful. We think it will be successful, but we do need to verify it through this 2- to 3-year experiment, to actually demonstrate how this technique will work in this particular instance.

We have other experiments planned with other agencies to look at other uses. The potential benefits are enormous. So far, there has been no major opposition from the international community.

ACCESS TO LANDSAT DATA

Mr. BAUCUS. Who will have access to that information?

Dr. FLETCHER. The information on the benefits?

Mr. BAUCUS. The information as to what crops are growing and what the conditions are.

Mr. TRAXLER. We are in the futures market.

Dr. FLETCHER. This is a very good point, Mr. Baucus and Mr. Traxler.

NASA is providing the technology and the techniques, but any information that was released on food would have to be released by the Department of Agriculture. As you know, information is treated extremely carefully for the reasons that you both gave, so that no interested group could take advantage of it in terms of the commodities market or in any other way.

The information would be released to all the users at the same time, at regular intervals, so that interested people, particularly farmers, could get a better idea of what the food situation is going to be like.

I happen to have a farm, for example, in the State of Oregon. It is important for a farmer to know, in terms of dealing with a buyer for a crop, what everybody else is going to be doing this year. Otherwise, the farmer gets the short end. So it benefits everybody. The Department of Agriculture has that responsibility and we supply the information to them.

POLICY ON RELEASE OF AGRICULTURAL DATA

Mr. BAUCUS. Is there an express policy as to how this information is released?

Mr. MATHEWS. Yes, Mr. Baucus.

The Department of Agriculture publishes information releases for every region of the world. The basic problem is that in some regions of the world, the accuracy of the information exhibits extreme variations. Some countries, like Canada and Australia, put out very accurate information which is then released to the U.S. public by the Department of Agriculture. In the case of some other countries, their systems are such that the information is not too accurate. Some countries that are major food producers do not put out any estimates at all.

CONTROL OF DATA RELEASE

Mr. BAUCUS. You do control the release of Landsat data?

Mr. MATHEWS. Yes.

Dr. FLETCHER. We control the release of data to the Departments of Agriculture, Commerce, and Interior. Those agencies distribute the data.

REGULATIONS ON LANDSAT DATA RELEASE

Mr. BAUCUS. I am wondering whether there are any statutory regulations as to release of data by the Department of Agriculture. It is not in your Department, but I am curious to know.

Mr. MATHEWS. Yes, there are regulations with respect to domestic and foreign release of the information. I do not have the exact details of it.

LANDSAT POTENTIAL FOR MINERAL EXPLORATION

Mr. ROUSH. Last year and over the past several years, I asked you about the possibility of using this satellite for exploration of minerals. Have there been any new techniques or new knowledge acquired in this area?

Mr. MATHEWS. Yes, although I want to qualify that by saying that no one has yet actually discovered oil or copper. Perhaps the reason is that normally the time period it takes for an exploration company's results to indicate that there is probably something there, to the time that a mining operation is going, is about 8 to 10 years.

I also do not want to say that the Landsat data would be the sole source of information that they would use. But, for example, there is a very interesting activity that occurred recently in Pakistan. There is a very mountainous area in Pakistan where copper mining operations are going on.

A Department of Interior geologist, using Landsat data, examined the area in which the copper was being mined and established that there were certain similar geological features and other characteristics in the close vicinity of this area, but in very rugged terrain that would be difficult to reach.

As I recall, this geologist established about 30 possible copper sources. He went to Pakistan and, working with the Pakistan Government, did examine about five of these possible sources. They were believed to be very significant geological discoveries as far as the geology of copper porphyry deposits is concerned.

Similar efforts have gone on in the United States, in Alaska, in terms of investigating other areas in the general vicinity of a known source.

One of the great advantages of Landsat data is that it can be used to correlate one set of geological features with similar features on the other side of mountain ranges. Landsat can provide systematic tracing of characteristics that are very difficult to see, but are critical for accurate geological analyses.

COST OF LANDSAT C

Mr. ROUSH. How much will Landsat C cost? What will be the total cost?

Mr. MATHEWS. The total cost of Landsat is in the range of $35 to $45 million, not including the launch vehicle or the development and procurement of the fifth-band multispectral scanner.

Mr. ROUSH. Mr. Traxler?

LANDSAT DATA PRINTOUTS

Mr. TRAXLER. I want to pursue for a moment a point that we made a moment ago.

The way the information is relayed back from Landsat, is it possible that sophisticated equipment can read the crop information—is that possible?

Mr. MATHEWS. Yes, sir. Mr. Traxler, people normally look at images that are formed from the Landsat data, but actually it comes down in the form of digital coded signals at a very high rate.

Normally, the more sophisticated users want the digital data transcribed onto magnetic tape, which is known as computer-compatible tape. That kind of tape can be directly fed into a computer. Then it can be manipulated to classify crops, to identify particular crops, for example; using the computer programs helps in that identification.

Therefore, you do not necessarily have to physically do an interpretation of a photograph. You can do it fairly automatically on a computer. This is also true in many other areas.

For example, if you are interested in certain classes of land use but only in its acreage and location, you can have the computer printout these different areas. For example, it is very easy for the Landsat information to differentiate a strip minded area. This has been done in Ohio, West Virginia, and Maryland, with a printout of the actual location of the strip mining activity and the size of the area that has been involved with that activity.

SAFEGUARDS ON LANDSAT DATA TRANSMISSION

Dr. FLETCHER. I think one point ought to be made clear which Mr. Mathews did not mention. That is, foreign stations can at the present time only read the information out that is taken by the satellite when it is in "line of sight" of their own country. We, however, use a tape recorder in the Landsat which can record what is happening all over the world, then we dump the information from the tape recorder down to our own stations on the ground. No one overseas receives that data dump. So the only place where one can receive all of the information, the global information, is at our own stations. The global data, of course, can be purchased from the data center at Sioux Falls.

The satellite must be programed by us to read out for foreign stations and we can safeguard that system to the extent necessary. So far, there has been no necessity to counter any compromise of the system.

We have signed agreements with five countries. Several additional ones are under consideration. They will have the obligation to distribute that information to any of the neighboring countries that ask for it, and again, they only get the information over their own neighborhood, not over the world.

As a matter of fact, they have agreed with us that after 1 year's operation of Landsat–2, we will have the option of charging them for the use of that satellite. So in summary, to obtain a global picture we use our tape recorder to read it out over our own stations. Nations making agreements with us can obtain their neighborhood pictures from stations of their own. We can preserve the integrity of that system as necessary.

SEASAT–A COST ESTIMATE

Mr. ROUSH. Turning to page RD 7–38, Seasat–A, last year you indicated that the total cost of this project would be a range of $35 million to $55 million, excluding the launch vehicle. Is that still the correct estimate?

Mr. MATHEWS. Mr. Chairman, our current cost estimate for Seasat–A is $50 million to $60 million, excluding the launch vehicle. Let me explain the basis for that change.

Mr. ROUGH. Yes, we would like you to.

Mr. MATHEWS. Last year, we had two alternatives on Seasat. One involved what we called a baseline system, a complete system, which is basically the type of system we are proceeding with; the other was a system with reduced capability. One of the systems evolved from a design-to-cost activity and the other system, the more expensive one, evolved from a user requirements activity.

Although we did somewhat reduce our requirements, we decided to proceed with the baseline system, because the user community needed types of equipment that would not be available in the less expensive version but would be available in the baseline system.

I believe last year we estimated a range from $35 million to $55 million and it is now a range of $50 million to $60 million.

Dr. FLETCHER. Last year's estimate was $35 million to $55 million.

Mr. TALCOTT. Is this without the booster?

Dr. FLETCHER. Yes, excluding the booster.

Mr. ROUSH. What would be the last year of funding for this program, if you know?

Mr. MATHEWS. In terms of the spacecraft development, the last year of funding would be fiscal year 1978. However, there would be some continued funding required in terms of supporting the operations. This would be at a relatively low level.

Mr. TALCOTT. May I ask a question?

Mr. ROUSH. Mr. Talcott.

SEASAT–A LAUNCH DATE

Mr. TALCOTT. What is the launch date in 1978?

Mr. MATHEWS. We have not yet established a specific launch date, but the middle of calendar year 1978 would be the approximate time period.

DIFFERENCE BETWEEN LANDSAT AND SEASAT

Mr. ROUSH. What is the difference between Landsat and Seasat? One is over the ocean and one is over land; that is what it sounds like, but it must be more complicated than that.

Mr. MATHEWS. There is indeed very different equipment involved in the two.

The Seasat system uses largely what is known as microwave equipment; some people call them "radars." The instruments are active. They send out a pulse of energy and then examine the return after that energy has reached the sea.

In the case of Landsat, we are looking at things in either the visible or the infrared light region. We are largely looking at reflected

sunlight, although in one case we are looking at the thermal or heat radiation coming off the land surface.

The significance is that one set of instruments is optimized for land surfaces and the other set is optimized for sea surfaces. The use is also quite different. For example, what we want to do is measure the sea state conditions over all the ocean areas to determine how rough the seas are. This information is extremely important in terms of routing ships to avoid damage to cargo or to the ships themselves, and in terms of improving the transit time of ships by avoiding storms. Ships of course have to slow down considerably in stormy weather.

There will be a device on Seasat called a radar altimeter, which can send pulses out, get a return, and measure the distance between the reflecting surface and the sending surface. This device can also be used for measuring the state of the seas. When the pulse hits the sea and comes back, if the sea is rough, this impulse of energy is reshaped because of the roughness. You can interpret from that reshaping how rough the sea is.

VALUE OF SEASAT

Mr. TALCOTT. So the Seasat research is really for the surface of the sea and not too much for what is in the sea.

Mr. MATHEWS. That is true, although many other things can be determined by inference. For example, if you know the main ocean current circulation patterns, it is valuable and can have very important effects on routing ships. You are all aware of the Humboldt current off South America. You also know that when the current moves, the fish move with it. The climate in those neighboring countries is also affected. As a result, you can gain considerable side benefits from a knowledge of the sea's surface in terms of what is occurring below the surface.

Mr. TALCOTT. You have been able to produce such fantastic information, discover such fantastic things about agriculture and the Earth food resources, yet the seafood resources may be even greater than on Earth.

Mr. MATHEWS. Seafood can be obviously very important.

Mr. TALCOTT. That is going to take another type of research.

DIVERSE USES OF SEASAT

Mr. ROUSH. Can you not measure the temperature of the sea and is that not very closely related to the fishing industry?

Mr. MATHEWS. That is correct, Mr. Roush. The movements of major currents can be measured by temperature and can also be measured in other ways using this equipment.

The knowledge of how pollutants are dispersed is also very important, because many wastes are dumped in the sea. If you know the ocean circulation patterns, then you can determine whether these wastes are really going out to sea or are going to be washed up on shore. Indeed, we have had situations where people thought they were dumping wastes to be dispersed at sea but the wastes were actually washing up on the beaches.

Mr. ROUSH. Which satellite measures the breakage of the ice, which is important to shipping, also?

Mr. MATHEWS. Seasat also measures that. Ice is important for two reasons. One is determining its location in terms of being able to establish shipping routes in the Arctic region. There is both new and old ice, and the difference can be detected. The new ice is the ice that comes and goes every year, so this establishes the loaction of the sea lanes.

In addition, the ice breaks occur when the temperatures from the ocean transfer heat into the atmosphere. The knowledge of these so-called ice breaks or ice leads is very important to meteorology. The basic source of the heat energy is really in the oceans and is transferred up into the atmosphere. Knowledge of this air-sea interface is very important in theoretical meteorology and in predicting weather conditions.

Mr. TALCOTT. I have no further questions. It is very fascinating, but I wish I were on that—what do they call the lottery up in Alaska? You could be very helpful on the date of the ice break; could you not?

Mr. Traxler wants to get into the grain market, but I want to get in on that lottery up in Alaska.

Mr. TRAXLER. Do you perceive that Seasat will replace the International Iceberg Patrol?

Mr. MATHEWS. I don't think Seasat will replace it, but it will probably reduce it in the same sense that weather satellites have reduced the need for the oceangoing meteorological ships of many countries. The ships themselves, of course, have the advantage of being able to make very direct, inplace measurements. But the problem with the ships, for meteorology or for any other purpose, is they can only be at one place at one time in a very broad ocean area.

That is why we know so little about oceans, because there are not many places that can be measured at the same time. In contrast, Seasat will give you very rapid information over very broad ocean areas.

AERONAUTICAL RESEARCH AND TECHNOLOGY

Mr. ROUSH. Let us turn to the aeronautical research and technology program.

I believe you deferred $13.5 million in fiscal year 1975 aeronautical research and technology funds into fiscal year 1976. Therefore, the obligations planned in fiscal year 1975 are $152.9 million and in fiscal year 1976, $188.85 million. Is that correct?

Mr. LILLY. That is correct, Mr. Roush. The $13.5 million that was deferred in the aeronautics area is included in the fiscal year 1975 column as part of the ongoing fiscal year 1975 program. It will actually be obligated, if it is not released prior to July 1, 1975, in fiscal year 1976.

Mr. ROUSH. Then the answer is that what I stated is correct.

Mr. LILLY. Yes, sir, those are the amounts to be obligated in those years.

DEFERRAL OF FISCAL YEAR 1975 FUNDS

Mr. ROUSH. The aeronautics program, for some reason or other, seems to bear the label of stepchild for NASA. Why was this area picked for such a large part of the total deferred? Who is the program director?

Dr. Low. Dr. Lovelace.

Dr. FLETCHER. He did not have the full responsibility for deciding where the deferrals were made.

Mr. ROUSH. First, I would like to know why such a large amount was deferred. Then I would like to learn from him whether or not this deferral has caused any special problems.

Dr. FLETCHER. Dr. Lovelace can address the impact. Perhaps Mr. Lilly would discuss the deferral decisions as a background for that.

Mr. LILLY. In terms of the decision on the deferrals, Mr. Roush, the determination was made in the Agency that we would try to minimize the impact of the deferrals on overall program schedules and total program costs. Therefore, we looked first at the areas where there were programs that had not yet started or proceeded very far into the development phase.

We deferred funds in flight programs which were in the early phase of development, such as Pioneer Venus and four applications flight projects. In the aeronautics area, the deferrals were applied in systems technology efforts and experimental programs.

NASA was required to defer $72 million of fiscal year 1975 budget authority, as part of the President's efforts to restrain Federal spending. This total was split fairly evenly across the program offices.

In terms of the specific impact of the $13.5 million in aeronautics deferrals, Dr. Lovelace will have the details.

Dr. FLETCHER. I would like to add one point to what Mr. Lilly said. We deferred a little over $13 million in the aeronautics area. We also deferred $16 million in applications, and $20 million in manned space flight operations. Although aeronautics may have taken a proportionately larger share, the dollar amount was not the largest.

Dr. LOVELACE. Mr. Chairman, I have carefully reexamined the impact of those deferrals on the aeronautics program, and if the deferred funds are made available in early fiscal year 1976, I do not anticipate any serious impact on any of the aeronautics programs.

RESEARCH AND TECHNOLOGY BASE

Mr. ROUSH. Turn to page RD 8–4, Research and Technology Base. There seems to be a constant shifting of names and functions, and it is very difficult for us to keep track of these programs. Give the committee a rundown of this program. Where are the priorities and concepts shifting to? From where are you taking funds and where are you adding money? Could you give the committee some examples of recent aeronautical research programs that have not yet worked out as you had planned?

Dr. LOVELACE. I can give a very brief statement this morning and if additional information is required, we can provide that for the record.

MAJOR FOCUS OF AERONAUTICS PROGRAM

A major area of focus in the aeronautics program, both this fiscal year and probably for the upcoming period, will be the technologies that relate to energy conservation in aeronautical flight. This embraces, as Dr. Low pointed out, about five areas in the aeronautics program.

Another key area is aviation safety. Safety has always been important in our aeronautical research and technology efforts.

We have a strong effort underway at the moment related to the generation of wake vortices and their impact on aeronautical transportation. In fiscal year 1975, we have not yet achieved the breakthrough that I think will be needed. It is an area that will also continue to receive attention in fiscal year 1976.

PROPULSION SYSTEM TECHNOLOGY

Mr. ROUSH. You mentioned this, but on pages RD 8–24 and 25, you discuss Propulsion Systems Technology. It holds a great deal of promise for aircraft fuel reduction, apparently, and also for quiet, clean turbofan engines.

REFAN PROGRAM

Of course, we have heard much of this insofar as it related to the refan program. That program seems to have gone by the wayside.

Now, are you convinced that this particular research will produce something useful? After all, if it cannot, we had better not start it.

Dr. LOVELACE. Mr. Chairman, I really could not agree with you more.

Let me make one comment on refan. The program is drawing to completion and has, I believe, represented a sound investment for the country as related to noise emission from aircraft engines.

Two points should be made with relation to the energy conservation programs in the aeronautics area:

One, they will not be done without full consideration of the other environmental considerations. To state that another way, I think it would be imprudent of us to optimize on energy conservation to the exclusion of other environmental impacts. That will not be done.

Two, the proof of the pudding is whether the technology gets used by the manufacturers and the operators of the aircraft who will be intimately involved in the program planning and throughout the execution of these programs. It is with their constructive assistance that we hope to help insure that the relevance and utility of the efforts will be maintained.

Dr. Low. Mr. Chairman?

Mr. ROUSH. Dr. Low.

Dr. Low. You commented that the refan program did not produce results. Technically, I think it produced the desired results, and we are now demonstrating those results.

Mr. ROUSH. I said that it seems to have gone by the wayside. I did not say that it had no results.

Dr. Low. As far as its use is concerned, we had hoped at one time that it might be applied to existing airplanes in a retrofit program. This is not taking place because of the expense involved in retrofitting airplanes. But the technology is available, and is being used by the aircraft engine manufacturers in proposing new engines for the next versions of the current airplanes.

I do not think that the refan effort was wasted; far from it. We will see airplanes flying using the technology as new airplanes are being built.

PROGRESS ON NOISE REDUCTION

Mr. ROUSH. If you will recall, last year the committee's report urged NASA and FAA to get together on noise reduction. Can you bring us up to date on what progress has been made in this regard?

Dr. FLETCHER. In response to the committee's recommendations, we have had a number of high-level coordination meetings with FAA representatives. In fact, these coordination efforts are continuing in other key aeronautics areas, as well as refan. But in refan in particular, the FAA Administrator, Mr. Butterfield, and myself have had several meetings in which we reviewed the program that NASA was doing, and also the program that the FAA was carrying on in terms of regulations. I think we are very well coordinated on that whole program at this point.

AVIATION SAFETY RESEARCH

Mr. TALCOTT. Could I ask what NASA is doing about aircraft safety research? You know four of our colleagues have been killed in the last 2½ years: Collins of Illinois, Boggs, Begich, and just recently Jerry Pettis from California. You know that is a pretty high average for any group of people.

I think the FAA seems to get involved in safety regulations after a crash such as the TWA flight with 92 people; it is surprising two or three Members of Congress were not on that. FAA seems to be doing a lot of things after the fact. Hopefully NASA does things before the fact.

Is there anything that you have done to make, not space travel but air travel safer?

Dr. LOVELACE. Yes, Mr. Talcott, I believe we are. I think it is reflected in the proposed fiscal year 1976 program. There is in excess of $10 million directly related to safety aspects.

We have given and are giving attention to a number of key areas. I will not repeat my statements on the wake vortex efforts, which are a very important problem relating to the mixture of aircraft, large and small aircraft, around our airports.

We are also looking at operating procedures. Some 50 percent of accidents occur in the approach and landing phase. Another 25 percent in the takeoff phase. We have what we call our "terminally configured vehicle" program, a study with the FAA on how we can upgrade procedures in the terminal phase and use the oncoming microwave landing systems that will be in the next 10 years installed throughout the country's major airports.

We are also focusing on general aviation, such as stall-spin research, in terms of: (1), prevention; (2), detection, if it cannot be prevented; and (3), the possibility of automatic recovery from stall-spin occurrences.

In addition, we are very much concerned about fire safety onboard aircraft: first, airborne fires because of hazard to the passengers and crew, but also fires in unattended aircraft on the ground, which have caused the loss of a good deal of capital equipment in the last few years.

Mr. TALCOTT. We know how much we allot to you in this research area, but sometimes we do not necessarily appreciate how the research is beneficial. I think that the significance is important for us to know.

NOISE REDUCTION REGULATIONS

Mr. ROUSH. Let's go back to the noise reduction problem.

Is the FAA rulemaking backing the "sound absorption material" the only treatment now in effect?

Dr. FLETCHER. No, it is not in effect at this time. We are in discussions with the EPA about whether or not to implement the new nacelle, which we call the acoustic nacelle. Of course, we are involved in the refanning aspects.

At the present time it does not look, as Dr. Low mentioned, as though we are going to require an additional rule to require refanning because of the very large investment required by the aircraft industry. Future aircraft engines will benefit from the technology.

Mr. ROUSH. How does EPA fit into this triangle?

Dr. FLETCHER. As I understand it, the EPA indicates, by publishing in the Federal Register, their intentions on reduction of aircraft noise. Then the FAA has a certain period of time to respond in terms of the technical feasibility or other factors.

On the basis of that, the FAA issues the regulations. FAA has the regulatory responsibility—they either come out with a regulation or they do not. To my knowledge, they have not had a situation where agreement was not worked out.

Do you want to elaborate on that, Dr. Lovelace?

Dr. LOVELACE. I could not really improve on your statement, Dr. Fletcher. I think that is the basic process.

Mr. ROUSH. Who has the regulation authority here?

Dr. FLETCHER. The rules and regulations are the responsibility, I think, by law, of the FAA. The EPA has authority to set standards for, monitor, and enforce requirements relating to all environmental areas. In a sense, they both have to be involved. But I think the final regulations on aircraft must be issued by the FAA at present.

REFAN RETROFIT

Mr. ROUSH. I understand it would cost about $170,000 to do the SAM treatment on a 727. This compares with a $1.92 million cost to refan the 727. Is that correct, and does the SAM treatment offer enough noise reduction to be worth the cost?

Dr. LOVELACE. Mr. Chairman, I will correct this for the record. I believe the figures that you quoted are indeed accurate ones. The second part of your question: Does the cost warrant the attendant reduction in noise? That is very much tied up in this regulatory process, in the overall standards we would like to apply.

I am afraid I would be very much out of my depth to comment whether that was indeed a worthwhile investment; clearly, it is like anything else, you get what you pay for. If you want more noise reduction, it will probably cost us more. If you want less, I think this is a matter of what can the industry, the users and operators of the aircraft stand in terms of the costs associated with these interim fixes, the retro-

fits, if you will, until such time as the new technology can be put in at the ground level—on the new design transports of the future.

[Additional response follows:]

The cost of SAM treatment on a 727 is given as $170,000 in 1973 dollars in the FAA draft environmental impact statement for civil airplane fleet noise requirements, December 1974. The latest NASA estimate of the cost to refan a 727 aircraft is $2,013,000 in 1974 dollars.

REFAN AS REALISTIC OPTION

Mr. ROUSH. Along this same line, I believe NASA estimated it would cost $5 billion to refan the 727, 737, and DC–9 fleet. At that cost, is the refan program a realistic option?

Dr. LOVELACE. I would have to do a little arithmetic on those figures, Mr. Chairman, as to the fleet mix of these aircraft, but it seems that you would probably not be able to refan the aircraft that you mentioned within those figures.

ESTIMATED COST OF REFAN RETROFIT

Mr. ROUSH. Would you like to do a little arithmetic and give us a better figure then?

Dr. LOVELACE. Yes, sir, I will do that.

[The information follows:]

The investment cost to refan the 727, 737, and DC–9 fleet would be $2.421 billion in current year dollars (reflecting 7 percent per annum inflation) as determined by the DOT 23-airport cost-effectiveness analysis of noise abatement alternatives, included in the FAA December 1974 environmental impact statement. The study also indicates $1.932 billion for additional costs attributable principally to increased cash direct operating cost and lost productivity on flights with maximum passenger loads and maximum range due to increased aircraft weight. There is substantial uncertainty in the costs associated with these factors.

The cost figure of $5 billion quoted by Mr. Roush is the approximate cost of both refanning the JT8D-powered aircraft and using SAM on the JT3D-powered aircraft. The figure includes both the investment costs and the other estimated costs of increased DOC and lost productivity.

Mr. ROUSH. The figure no doubt would be higher?

Dr. LOVELACE. I suspect it would be a little higher than that.

Mr. ROUSH. If it is higher, would it be a realistic option, either at this figure or at a higher figure?

Dr. LOVELACE. I think that, yes, it could be a realistic option if some way were found to amortize those costs within the operating fleet. It is not clear to me at this point how the airline operators would amortize those costs.

Mr. BOLAND. By increasing their rates, of course.

Dr. LQVELACE. Yes; at a time when their business is suffering, as are other segments of the economy.

SUPERSONIC CRUISE AIRCRAFT RESEARCH

Mr. ROUSH. You are again requesting $8.9 million for supersonic cruise aircraft research. I participated in the SST debate on the floor. I know you have told us that this program is designed solely to advance the state of the art and not to build a supersonic transport. Is

that still the case, and if that is the case what are your ultimate objectives here?

Dr. LOVELACE. Mr. Chairman, I can assure you that is still the case.

If I had to state very simply what our ultimate goal is in this program, it is to maintain for the United States the technological capability to undertake a supersonic transport development, should the Congress and the country decide that it is wanted at some future date. Our supersonic cruise aircraft technology would provide technical areas of excellence. However, our efforts are aimed at maintaining a sound technology base, not at building a supersonic transport.

It is, further, of importance to the military and consistent with our responsibility in aeronautics, to have NASA conduct this technology effort.

It is also of importance to the United States because of the fact that supersonic transports manufactured by other countries will be operating. We need to understand the technology as it may relate to the environment, the fleet mix problems, and so forth, at our airports.

Mr. ROUSH. Is NASA doing work for the military in this area?

Dr. LOVELACE. In the area of supersonic cruise aircraft research, I would say most of the $8.9 million is against keeping the options open in terms of the civil sector. We do support the military in part through the work with the YF–12, which is the only aircraft available to us for doing supersonic cruise experimentation.

Mr. ROUSH. The military is also doing research in this area; are they not?

Dr. LOVELACE. Yes, they are.

Mr. ROUSH. Do you have a committee, or do you have a means of coordinating the research which you are doing with that which is being done by the military so as not to have a duplication of effort?

Dr. LOVELACE. Yes, we do. I might mention that Dr. Low and Dr. Currie, who is the Deputy Director for Research and Engineering for the DOD, cochair the Aeronautics and Astronautics Coordinating Board (AACB). There is a subpanel on aeronautics of which I am a cochairman. There are many areas, but this is one of the areas that receives careful scrutiny.

We not only examine programs; we examine priorities. At the working level there are many interfaces.

NASA–DOD DIVISION OF LABOR

Mr. ROUSH. I think that 2 years ago you supplied for the record a breakdown on this division of labor between NASA and the military. Could you do that again?

Dr. LOVELACE. Yes, sir. I am not personally familiar with the prior input, but I am sure we can provide that information.

[The information follows:]

The material supplied 2 years ago indicated that there was a continual exchange of detailed information on technology programs and plans between the Department of Defense and NASA at all levels; the major coordination being accomplished under the auspices of the Aeronautics Panel of the DOD/NASA Aeronautics and Astronautics Coordinating Board. The aeronautics panel sponsors a supersonic technology subpanel which reviews and coordinates both DOD and NASA supersonic technology programs and defines critical areas where research is lacking and promising technological opportunities for additional

research exist. This activity continues to perform its designated function remarkably well. During December 1974, the subpanel conducted a formal review of the program's status and examined the activities relevance in light of the energy situation and changing military requirements. The review identified that NASA's existing SCAR program continues to be the major existing technology program for providing supersonic cruise technology. However, the findings of the subpanel pointed out deficiencies in the technolgy programs addressing the speed regime beyond mach 3. (SCAR addresses technology applicable to primarily the mach 2.2 to 2.7 regime.)

The Air Force view of NASA's program, as expressed in the subpanel report was that the "Air Force is, therefore, looking to NASA to * * * continue to develop and expand a technology base that will permit the development of efficient supersonic cruise aircraft." This is still viable and accurate.

In the general area of supersonics, the Air Force has maintained a program supporting improvements for future fighters, interceptors, bombers, missiles, drones, and even bombs that fall in the supersonic speed regime. The Air Force defines the supersonic speed regime as extending from mach 1.5 to 4.5. Their work is divided into six general areas of endeavor: Systems studies (demonstration program), survivability/vulnerability, propulsion, aerodynamics, guidance and control, and structure/materials. Of these six areas, propulsion receives roughly 75 percent of the effort.

Research which is applicable to future military or civil supersonic cruise aircraft is also carried out in the joint NASA/USAF YF–12 flight experiments program. Flight experiments are conducted to validate predictive techniques and are supported by wind tunnel and propulsion systems tests of YF–12 models and engines. The aircrafts are supplied by the Air Force and the research is funded by NASA. The Air Force has provided funding support for the program in the past and plans to in the future but in fiscal year 1976 Air Force support is limited to personnel assigned to the support phases of the program.

CONCORDE FLIGHTS

Mr. BAUCUS. Yesterday, I think it was, the FAA announced that they want the Concorde to fly to Dulles and JFK. I am wondering whether you advised FAA as to the environmental problems and the mix problems that you referred to?

Second, what is your independent estimate as to the advisability of Concorde's flying to this country?

Dr. LOVELACE. I read that in my morning paper. I picked up a copy of the Department of Transportation announcement on this. To answer your question very specifically, the Federal Aviation Agency has neither approved nor disapproved this yet. FAA has, on the basis of an environmental impact statement that they have worked up, announced that under worse case conditions, they really do not see this as a serious environmental problem.

We are one of their principal technical advisers to FAA, and I think we are wholly consistent with their position.

These aircraft, and the way that they will be utilized, will be no more of a complication than current jet aircraft of, for example, the 707 variety, which I believe you are familiar with.

Mr. BAUCUS. Did the FAA consult with you?

Dr. LOVELACE. Yes.

Let me add just one step to Dr. Fletcher's enumeration of the process. We consult with EPA regularly. We are on the pollution committee and subcommittees. We biannually review with them noise reduction considerations, including their intentions and the goals that they plan to set.

On a day-to-day basis, we in turn work with FAA and provide them with comments. When FAA puts out a proposed notice of rulemaking,

which is an advance announcement to the public of what they intend to do, we have the opportunity at that stage to comment again. So we do participate very directly in that process.

Mr. BAUCUS. If I understand what you are saying, it is your judgment that Concorde flights, whatever the frequency, would be to Dulles and JFK, is not in your view significantly harmful to the atmosphere, noise levels, or anything else.

Dr. FLETCHER. May I address that question? I believe that Dr. Lovelace is saying that the Concorde is not significantly different from 707's. We think there is a future potential for reducing the noise level of 707's, as well as Concordes. We think that it is possible that future airplanes may have a sufficiently small noise level to confine the noise to the airport area so that it would not bother the people living around the airports.

Dr. LOVELACE. The technology associated with the Concorde is early technology, and I would have to say that we do not find fault with the Concorde's environmental statement from FAA.

I would point out that the anticipation is that initially there would be four flights a day into Kennedy and two into Dulles. On that basis, you have relatively low frequency compared to the number of flights of wide body jets that may travel the same routes. I can assure you that from a technical standpoint we do not find any reason to take exception to the facts stated by FAA, should allowances be made for the Concordes to land.

Mr. BAUCUS. Thank you.

TILT ROTOR RESEARCH AIRCRAFT

Mr. ROUSH. Let us move on to the tilt rotor research program.

I notice that the fiscal year 1976 requirements decreased to $1.9 million, compared with $11.3 million in fiscal year 1975. Is this program about wrapped up, and if so, what have we learned from it?

Dr. LOVELACE. Mr. Chairman, this particular program is indeed about wrapped up, as you see by the funding profile.

Rollout of the first of two tilt rotor research aircraft probably will occur later this year. As to what we have learned, our learning will start when we get the research aircraft into the air for tests.

Our learning process really starts when we get this tool, the research aircraft, operational.

Mr. BAUCUS. What is your objective?

Dr. LOVELACE. To provide research aircraft for evaluating a concept called tilt rotor. We believe this is an important concept to be evaluated, along with other concepts, to provide for the possible selection of tilt-rotor, lift-fan concepts, for commercial and military applications. We need to get data to evaluate the concept.

We need to understand its performance characteristics to understand the engineering range of parameters which will allow us to go back and assess this concept compared with other concepts.

Dr. LOW. The test objectives will not start until the research aircraft is delivered and is flying.

Mr. ROUSH. From what places will it fly?

Dr. LOVELACE. Eventually it will fly principally from the Flight Research Center located at Edwards Air Force Base.

SPACE AND NUCLEAR RESEARCH AND TECHNOLOGY

Mr. ROUSH. On page RD 9–1, you are requesting $74.9 million for the space and nuclear research program in fiscal year 1976. This is up slightly from fiscal year 1975. I notice that the transition level of $22.3 million would represent an annual level of about $90 million. Where is the big increase coming in this program?

Dr. LOVELACE. Mr. Chairman, and we can reexamine this and provide more information for the record, that the funding requested for the transition period is not based on a straight percentage factor. The funds requested for this 3-month period of transition to the new fiscal year represent the requirements to carry on the programs contained in the fiscal year 1976 budget.

I will be glad to provide that information for the record.

Mr. ROUSH. If you will do that.

[The information follows:]

We have reviewed the funding requirements for the space and nuclear program during the 3-month transition period. The amounts requested reflect the estimated funding requirements of ongoing 1976 programs during this period. Normal conditions in the space R. & T. base activities require up to 30 to 33 percent of the annual funding in the first quarter of the fiscal year. This is due principally to the need for renewing a large number of in-house support activities at this time. The renewals historically occur during the first quarter of the fiscal year. In the future, the timing of renewals of these efforts may be shifted to the early part of the new fiscal year. The requested amount is based on smoothing the transition without unduly increasing the administrative and procurement workload. The projected level for a 12-month period, however, remains around $74 million.

Dr. LOW. You are saying that this is the way the funding is distributed throughout the year and does not signify an increase for the total year of 1977.

Dr. LOVELACE. Exactly.

Mr. ROUSH. The committee stands adjourned until 1:30 this afternoon.

AFTERNOON SESSION

Mr. ROUSH. The committee will come to order.

ENERGY TECHNOLOGY APPLICATIONS PROGRAMS

We will now turn to Energy Technology programs on page RD10–1.

Dr. LOW. Dr. Harrison Schmitt, our Assistant Administrator for Energy Programs, will be our chief witness, Mr. Chairman.

SOLAR HEATING AND COOLING RESEARCH DEVELOPMENT AND DEMONSTRATION

Mr. ROUSH. As we all know, the solar heating and cooling program has been transferred from the National Science Foundation to the new Energy Research and Development Administration. We provided NSF $5 million in transfer authority to implement the Solar Heating and Cooling Demonstration Act. Those funds were scheduled for transfer to NASA and HUD. Have you ever received money for that program and what is the status of that effort?

51-423 O - 75 - 31

Dr. SCHMITT. No, sir; we have received no transfer of funds and the status is that ERDA is in the process of assimilating all previous planning and attempting to come to grips with what will be called a National Plan for Solar Heating and Cooling Research, Development and Demonstration.

As I recall they expect to transmit to the Congress a report on that activity, on March 15.

ROLE OF NASA IN SOLAR HEATING AND COOLING

Mr. ROUSH. Do you expect to receive any funds in fiscal year 1975?

Dr. SCHMITT. Frankly, we are not sure right now.

Mr. ROUSH. Do you hope to?

Dr. SCHMITT. We hope to. We would like to participate and we believe that we have the capability and expertise to participate in that effort.

Mr. ROUSH. To what extent would be your participation?

Dr. SCHMITT. Again, the extent of NASA's participation is difficult to assess until we have an opportunity to review the results of the ERDA planning effort. The areas where we would be most competent would be in test and evaluation of existing systems; systems development related to the advancement of the present state of the art and systems integration of components and subsystems; and in advanced research and technology. Those are the types of efforts where we feel we can make a useful contribution.

Mr. ROUSH. What is this year's level?

Dr. SCHMITT. This year's level in NASA, for 1976, we have no program funds. We are asking for no funds in solar heating and cooling.

NASA'S REIMBURSABLE ENERGY EFFORTS

Mr. ROUSH. How much energy work is NASA doing on a reimbursable basis for other agencies, in addition to the $5.9 million requested for Energy Technology Applications in your fiscal year 1976 budget?

Dr. SCHMITT. In fiscal year 1975, we currently anticipate reimbursable energy funds on the order of approximately $10 million. So far, we have about $6.2 million available in reimbursable funds for obligations. The amount changes, as you might expect, from week to week.

In fiscal year 1976, I personally feel that it is very likely that we will at least double and possibly triple the amount of reimbusable work for other agencies.

Mr. ROUSH. Will any of this work be transferred then from ERDA?

Dr. SCHMITT. Some of it already has been. Some of the ERDA programs have been inherited. ERDA has inherited them from agencies such as the NSF, Department of the Interior and EPA.

We are continuing to conduct, under ERDA's auspices, those programs that had started before the creation of ERDA.

EXAMPLE OF NASA'S REIMBURSABLE ENERGY EFFORTS

Mr. ROUSH. Specifically, what are you doing for other agencies?

Dr. SCHMIDTT. Of the programs that came from the NSF there were two major ones. One in low-cost silicon solar array technology, which will be funded in fiscal year 1975 at about $3 million. We are not yet sure of the level of funding in fiscal year 1976. That amount has yet to be negotiated. The second major effort is a wind turbo-generator program for electric generation, using wind energy. That is on the order of $2 million in fiscal year 1975. The amount for fiscal year 1976 is not yet certain. It will be funded; the question is at what level.

In terms of EPA projects transferred to ERDA, NASA's work includes one associated with lean burning engines, one on the advancement of gas turbine technology for automobiles. From the Department of the Interior, ERDA inherited a project that was partially funded by the Department of Interior's Office of Coal Research, partially funded by NSF and partially by NASA.

The project has to do with the comparison of large-scale energy conversion systems that would use coal or coal-derived fuel. It is commonly known as the Energy Conversion Alternatives Study—ECAS.

COORDINATION WITH NSF AND ERDA

Mr. ROUSH. Do you feel that your coordination with NSF and now ERDA has been satisfactory?

Dr. SCHMITT. By the time ERDA came into being, we had worked out a reasonably satisfactory coordination arrangement with the NSF under the auspices of the interagency agreement signed last year.

We are still in the formative stage of establishing the relationship with ERDA. We are now negotiating an interagency agreement with ERDA. Having activities already underway with ERDA should simplify that process. Since we are already working together, it should simplify an acceleration of that effort.

Dr. LOW. Dr. Schmitt and I have been meeting with Dr. Seamans, the Administrator of ERDA, on about a weekly basis to discuss with him the kinds of work we could be doing for ERDA, using NASA's capability. We have received Dr. Seaman's expression of interest in utilizing NASA equipment and utilities for ERDA activities. The precise nature of the work will be defined as the ERDA plans evolve.

Dr. SCHMITT. Another project that would be of interest to the committee is a $400,000 effort funded by the former AEC. We are assisting them in the update of a design study on a test facility that is related to a high temperature gas reactor system. It is a test facility that would be related to the use of a direct-cycle helium gas turbine engine as the energy conversion system for use with high-temperature gas reactors. That is one of the reimbursable efforts.

NEED FOR TIMELY TECHNOLOGY TRANSFER

Mr. ROUSH. I would express the same concern here that I expressed with the NSF people. We seem to have difficulty in transferring the knowledge which we obtain into practical usage. So much of this technology and knowledge is on the shelf. The lag may be due to the system or it may be due to the money involved. But still, it seems to me that this Nation which, through its technology, created so many problems, surely could solve these same problems through its technology.

I am concerned about the pace of transferring our technology into practical usage. I am sure it is also of concern to you, although it may not be your primary concern. Maybe that should be the concern of some other agency. However, I know NASA has been one of the leading agencies when it comes to technology transfer.

Dr. SCHMITT. Mr. Chairman, I would say that the transfer of energy technology is one of our primary concerns. That is the main reason why the Energy Programs Office was established by NASA and I think continues to be a prime concern. We are exploring how our aeronautics and space technology, which forms one of the basic foundations upon which we can now do new things, can be transferred and applied to the problems facing our society, particularly the energy problems.

That is why we are working so very hard with the new Energy Research and Development Administration, the Department of the Interior, the Department of Transportation, the Department of Housing and Urban Development, and the Environmental Protection Agency to create the arrangements by which that transfer can occur.

I do not want to belittle the difficulties inherent in that process. It is a process that deals with people, traditions, legal precedents, and transfer of money. That takes time.

PROGRESS ON SPACE-BASED SOLAR SYSTEM STUDIES

Mr. ROUSH. Let me ask you once again what progress is being made in the research being conducted concerning potential application of solar energy? I am speaking, of course, of space research.

Dr. SCHMITT. We have made considerable progress with the work at the Marshall Space Flight Center in the demonstration of solar heating and cooling systems.

Dr. FLETCHER. Mr. Chairman, I think you are probably referring to the transfer from space of solar power for use on Earth.

Mr. ROUSH. Yes.

Mr. FLETCHER. I think we have made considerable progress on the potential and feasibility of space-based solar power systems. As you know, we sponsored earlier studies of that system. There were uncertainties in these early studies, such as the cost of solar cells and the technical problem of transmitting this solar energy power through a microwave system down to the Earth. We have set up a small internal group and we are reviewing the various aspects of that approach piece-by-piece to determine the key technical problems. NSF has also invested substantial sums in one element of that effort, namely, the re-

duction of the cost of the solar cells, which is a significant part of the total system.

We have also tried experiments transmitting amounts of microwave energy from one part of the Earth to another, in this case out in the Mojave Desert. All of these study efforts are being reviewed and integrated.

Although the application of this type of energy system is a long way down the road, we are becoming more optimistic about the feasibility of collecting sizable amounts, thousands of megawatts of solar power, and transmitting it down to Earth.

For the new members, this space-based solar power system would be a large array of solar cells, perhaps 3 or 4 kilometers on a side, in a stationary orbit. It would be over one part of the Earth all the time, collecting solar energy, converting it, and transmitting it down to microwave receivers on the ground for use in utility systems. This system would be similar to the Boulder Dam and Hoover Dam projects. The feasibility of a space-based solar power system looked a bit far out when we first considered the concept. But if you analyze the pieces one-by-one, it does look as though it might possibly be a viable approach beginning in the years between 1990 and 2000, in that time period when relatively easy access to space is possible by a Space Shuttle type vehicle.

Mr. TRAXLER. The UPI teletype quotes a prediction of 25 years. This is just hot off the teletype. I am not sure which one of your companion agencies issued that statement, but you will probably read it in tomorrow's paper.

Dr. SCHMITT. I might add that the effort we presently have underway, the satellite power system team as we call it, is headed by Dr. William Lenoir of the Johnson Space Center and this team is looking at each of the potential ways of generating solar power in orbit around the Earth and relaying power from one point on Earth to another by using a relay satellite. The group is also attempting to establish the technical and economic parameters that will govern its feasibility. We are looking at futuristic competitors of such a system and trying to determine the economic and technical feasibility.

We identify, within the technology required for satellite power systems, those critical technologies that need to be studied in order to make a sound technical and economic assessment. One area we will be concentrating most of our fiscal year 1976 funding on is the transmission of microwave energy at high efficiences. Any satellite power system is going to take large amounts of microwave energy to transmit the power through the atmosphere.

COLLECTION OF SOLAR ENERGY

Mr. ROUSH. How would you collect the solar energy?

Dr. SCHMITT. You would collect solar energy through either solar cells or thermal collectors, using a turbine system to generate the electricity, convert it to microwave, and transmit it down to Earth to the receivers.

Mr. ROUSH. Is there any limit on the distance from which it can be transmitted?

Dr. SCHMITT. There would be a limit.

POSSIBILITY OF SOLAR POWER BASE ON THE MOON

Mr. ROUSH. Let me ask you, you are an authority on the Moon, are you not?

Dr. SCHMITT. Yes, sir, I hope so.

Mr. ROUSH. You are 1 of 12 people who has stood on the surface of the Moon?

Dr. FLETCHER. And Dr. Schmitt is the only scientist who ever walked on the Moon.

Mr. ROUSH. Why could we not use the Moon as a base for the receipt of this solar energy and for the transmitter which would send the power to the Earth?

Dr. SCHMITT. Potentially you could, Mr. Chairman. However, the transportation costs would probably make it prohibitive. It looks, at the first cut at any rate, that the establishment of a geosynchronous satellite is a much more economical means of doing it.

STUDIES ON SPACE-BASED SOLAR ARRAYS

Mr. ROUSH. Would that not require a tremendous array of panels out there?

Dr. SCHMITT. It will, based on the concept of solar cells, require a 7-kilometer diameter receiving array.

One of the biggest problems involves accustoming one's self to the consideration of the size and weight of this type of solar power system.

Again, we are not necessarily considering ourselves advocates. We are looking at all the factors as objectively as we can. Based on very preliminary study data on the estimated costs, it is not as far out of the ballpark as most of us thought it would be.

Mr. ROUSH. When Dr. Von Braun appeared before this committee 2 or 3 years ago, he made it seem rather simple, did he not, Mr. Talcott?

Mr. TALCOTT. I worried about pointing the transmitter to the right spot on Earth, fearing it might cause burn spots.

Dr. SCHMITT. First of all, the concept would involve a very diffuse microwave beam. However, I do not want to underestimate the fact that we do not yet fully understand the microwave emissions. That is a purpose of our future studies. But the way you diffuse the beam is to build your antenna larger and larger. For what seemed to be a reasonable level of microwave intensity, a receiving array about 7 kilometers in diameter would be needed.

ENVIRONMENTAL EFFECTS

Mr. TALCOTT. Are you impeded by the environmental impact reports that you have to make?

Dr. SCHMITT. Not at this point.

Mr. TALCOTT. That is pretty scary.

Dr. SCHMITT. We want to know more about it. We cannot file a report now because we do not know enough about the subject. We are conducting studies. Eventually that would have to be done; no question about it.

Mr. ROUSH. I though Dr. von Braun said cows could graze among these beams.

Dr. SCHMITT. That is probably true.

Dr. FLETCHER. We think that is probably true. However, we are entering a new area here and we want to be sure we are right before large amounts of money are spent on this type of energy collection system.

Mr. TALCOTT. I had the impression that for a nuclear powerplant, which probably does not have as much power as what you are visualizing, you have to get all sorts of environmental impact studies, month after month after month over years and years.

I would think you are dealing with a lot more power and that might have even more serious risk to it. Yet you people do not seem to be concerned about environmental impact.

Dr. SCHMITT. We are very much concerned and do intend to conduct environmental impact studies. However, we have to complete the basic feasibility studies first.

Dr. FLETCHER. The actual impact on the environment of a system like this is probably a great deal less than any other kind of energy production mechanism. For instance, you do not generate the heat on Earth; you generate the heat in space. Therefore, you do not have to worry about thermal effects.

There would not be radiation effects in the sense that nuclear devices have. The effects of large amounts of microwaves relayed from space will, of course, be analyzed.

Just as an example, the densities of these microwaves would be much less than the emissions from a microwave oven. Precautionary measures are taken on a microwave oven. We are not talking about anything like that density, much less. The chances are that Dr. von Braun is right; there probably would be no serious effects from microwave energy transmitted from space. We will be studying that subject.

Mr. TALCOTT. Talking about receiving impulses from quasars, or other high energy sources, it could be something like a reverse laser, from what I understand, and that could be pretty dangerous.

Dr. SCHMITT. The microwave beam would be extremely diffuse. The energy intensity would be very, very low in a space-based solar power system.

When one starts transmitting, the beam is very concentrated. How broadly one diffuses that beam depends on the facilities on the ground.

Mr. TALCOTT. I am pleased that you are starting out not frightening anybody about what things can happen from space. I think if the nuclear power people started out that way, we would have a lot less problems now.

Dr. SCHMITT. We want to be sure that any new technology of this kind has been evaluated in terms of its total impact on the society and on the environment. We see no point in proceeding faster than that knowledge. I think the same applies to many other areas the application of space and aeronautics technology which we have discussed.

Mr. TALCOTT. Have you had any personal adverse effects from being to the Moon?

Dr. SCHMITT. You will have to ask my friends, but I have not had any apparent adverse effects.

Mr. TALCOTT. I am talking about physical effects.

Dr. SCHMITT. I know of none.

Mr. TALCOTT. Everybody exposed to a certain experience is going to have some effects.

Dr. SCHMITT. I know of no adverse personal effects from the mission.

Mr. TALCOTT. Did you go through the same training that the other astronauts did?

Dr. SCHMITT. Yes, I did, Mr. Talcott.

Mr. TALCOTT. So you have done everything else and more?

Dr. SCHMITT. Yes. I received the same training as they did.

Dr. FLETCHER. I knew Dr. Schmitt before and after the Apollo 17 mission, and I would say that the effects were all positive, not adverse.

Dr. SCHMITT. Thank you, Dr. Fletcher.

POWER POTENTIAL OF SPACE-BASED SOLAR POWER SYSTEM

Mr. BAUCUS. How much power is forecast for this project?

Dr. SCHMITT. We need to complete our technical and economic studies before we can make a sound estimate. By the same token, we do not yet know enough about futuristic nuclear systems either.

However, as a general comparison, our study effort is looking at a 10,000-megawatt system in orbit. That compares to about 1,000 megawatts for the average new nuclear plant presently being designed.

Mr. BAUCUS. Is that 10,000 megawatts that could be delivered?

Dr. SCHMITT. That is what we are trying to deliver.

Mr. BAUCUS. Deliver to the power lines?

Dr. SCHMITT. Deliver 10,000 megawatts to the bus.

Mr. BAUCUS. To the bus?

Dr. SCHMITT. To the power lines. We are trying to get 10,000 megawatts out of the station as a starting power. Of course, with solar cells you would be generating much more than that in orbit, within your total system. In time, that efficiency will degrade. Over a 30-year period, you may end up at about 5,000 megawatts for the lifetime of the plant, whatever you may decide that your amortization life is.

Mr. BAUCUS. Thank you.

TRACKING AND DATA ACQUISITIONS

Mr. ROUSH. Are there any other questions?

We will move on now to "Tracking and data acquisition," which begins on page RD 11–1.

Dr. Low. Mr. Gerry Truszynski.

Mr. ROUSH. When did we first sit across the table from each other Mr. Truszynski?

Mr. TRUSZYNSKI. In 1961, I believe.

Mr. ROUSH. That has been a while back?

Mr. TRUSZYNSKI. Yes, sir.

Mr. ROUSH. You are still the head of tracking and data acquisition. You just have to be the most knowledgeable person in the world on this.

Mr. BOLAND. He is.

Dr. FLETCHER. That is correct.

Mr. TRUSZYNSKI. Thank you.

TRACKING AND DATA RELAY SATELLITE SYSTEM (TDRSS)

Mr. ROUSH. I am glad you are with it still.

Can you bring us up to date on the new satellite tracking network planned, the tracking and data relay satellite system?

Mr. TRUSZYNSKI. Yes, Mr. Chairman.

Since our appearance before your subcommittee last year, when we outlined the general concept of the tracking and data relay satellite system and the approach we were planning to take, we have made considerable progress. We have completed the request for proposals for obtaining this capability through leased services. The request for proposals has been released to industry, and industry is currently preparing their responses. We expect to receive those responses about a month and a half from now and then we will start our evaluation process.

The schedule that we have is still for obtaining leased services through the new tracking and data relay satellite system in the latter part of 1979. Our schedule is basically the same as it was last year.

STATUS OF MADAGASCAR STATION

Mr. ROUSH. Do we have any political problems with any of your tracking stations now which might endanger them or cause you to move to alternate sites?

Mr. TRUSZYNSKI. Mr. Chairman, as you probably read recently in the newspapers, there is currently political unrest in Madagascar, where we have one of our stations. However, I can report that our station basically has not ben affected, in the sense that the station personnel have not suffered because of the military activity.

However, communications to and from the Madagascar station have been interrupted. This is part of a general disruption of communications because of the political situation. However, we get almost daily reports and are kept up to date through the embassy communications system. We expect station communications to be reestablished in the very near future so that the station operations can resume.

Mr. ROUSH. Is that station essential to the network operations?

Mr. TRUSZYNSKI. Mr. Roush, it is an important location because it does support launches out of the Western Test Range. However, in terms of its criticality, in launch operations, we can provide a contingency support for the launches through other means.

While we would rather use the Madagascar station, we do have a contingency approach which can provide an interim support capability for launches out of the Western Test Range. The contingency approach provides a lesser capability at more expense because it requires greater use of the tracking ship.

COST OF TRACKING AND DATA RELAY SATELLITE SYSTEM

Mr. ROUSH. Last year you indicated that NASA had opted for the leased tracking and data relay satellite system instead of a NASA-owned system. As I recall, a NASA-owned system would cost about $300 million, but the leased system would run approximately 20 percent more.

What do the latest cost figures show and does your decision of last year look better or worse now?

Mr. TRUSZYNSKI. Mr. Roush, during the last year, we continued to update our lease-versus-purchase study of the tracking and data relay satellite system. We included items which were not equitably included in last year's studies. These are items such as equalization of the launch costs in both cases and the inclusion of the cost of civil service personnel on each side of the equation.

The result is that the leased costs approach the buy costs on the basis of discounted dollars and in essence the least-versus-buy ratio is about equal.

Mr. ROUSH. And you are satisfied with the arrangement?

Mr. TRUSZYNSKI. Yes, Mr. Roush, I think I can say that confidently.

RETENTION OF CORE TRACKING STATIONS

Mr. ROUSH. Last year you told us that when the new TDRSS system is operational, you would retain three deep space ground stations plus five other supporting stations. Would you identify each of these stations. I believe you have indicated that there has been no change of plans. Is that correct?

Mr. TRUSZYNSKI. Yes, Mr. Roush. The residual core stations, as we call them, would be retained in Australia, California, Spain, Alaska, and North Carolina. These stations would remain for support of the planetary missions and synchronous satellites.

In addition, we would retain a very small capability for launch support at Cape Kennedy, Bermuda, and Madagascar.

NET SAVINGS FROM USE OF TDRSS

Mr. ROUSH. You told us last year that the remaining ground stations would cost about $70 million annually to operate. How much will the new leased system cost annually above the $70 million?

Mr. TRUSZYNSKI. Mr. Chairman, I think maybe the best way for me to answer that is in terms of the net savings by use of the tracking and data relay satellite system. The net savings over the current way we operate our networks will be on the order of $30 million a year.

Mr. ROUSH. Are there further questions?

TRACKING AND DATA ACQUISITION FOR APOLLO-SOYUZ TEST PROJECT

Mr. TALCOTT. I have a couple of questions I would like to ask with regard to tracking as it pertains to the Apollo-Soyuz test project.

Do we have adequate tracking facilities for that mission?

Mr. TRUSZYNSKI. Yes, we do, Mr. Talcott. We will be using our entire network, 15 stations, essentially as configured for the Apollo missions. We have that capability today.

Dr. Low. In addition to those stations, we will use the ATS–6 communications satellite for the Apollo-Soyuz test project.

Mr. Talcott. That is more than we have had.

Dr. Fletcher. That is correct, Mr. Talcott.

Mr. Talcott. How about the Russian tracking stations; are they going to be available for use on that flight?

Mr. Truszynski. Yes, the system configuration is that we will track our ASTP spacecraft with our network, and the Soviets will track their Soyuz spacecraft with their network. However, we have an intercommunications link so that we can actually transmit from our Mission Control Center through one of their stations to our spacecraft. There is compatible communications equipment on each spacecraft. In that sense, we will have the use of both nations tracking networks.

ASTP COMMUNICATIONS COVERAGE

Mr. Talcott. Compatible communications equipment.

There is a fellow by the name of Victor McElheny—you all know him—from the New York Times Service. He says in a recent article that the astronauts in space will have to rely on the command of their own languages to communicate. When the two spacecrafts are in orbit, they will be in contact with ground stations only about half the time.

That sounds like it could be pretty dangerous to me.

Dr. Low. The communications capability for the Apollo-Soyuz test project mission will be greater than we had in any other Earth orbital flight because we will be able to use the Applications Technology Satellite, ATS–6.

Mr. Talcott. But the situation is different. It would require more apparently, even with the extra satellite you have, and even with the tie-in with the Russians' tracking stations.

He still says when the two spacecrafts are linked in orbit, they will be in contact with the ground stations only about half the time. Have we had less communication than that before?

Dr. Low. We have had far less than that before.

In Skylab, there were times where we only communicated 3 or 4 minutes out of a 2-hour period.

Mr. Talcott. So these are not risky or unsafe?

Dr. Low. They are not risky or unsafe. We have designed the mission to use the network of ground stations that we have, plus the ATS–6 communications satellite. We will actually have more communications coverage during the Apollo-Soyuz test project flight than we have ever had in manned Earth orbital flights.

Mr. Talcott. All right. We do not have to be nearly as worried about it as the New York Times Service suggests?

Dr. Low. I would like to see that article if I may.

MADAGASCAR STATION—INVESTMENT AND STAFFING

Mr. Boland. With respect to Madagascar, what is our own investment there?

Mr. Truszynski. It is about $15 million, Mr. Chairman.

Mr. Boland. And how many personnel?

Mr. TRUSZYNSKI. We have currently about 50 American contractor personnel. There is a significant number of indigenous Madagascar personnel for a total of about 250 people. That is the split at the moment.

Mr. BOLAND. What would be the cost of the personnel at Madagascar?

Mr. TRUSZYNSKI. Operations costs run about $3 million a year in total.

Mr. BOLAND. Are these political problems that we are faced with down there?

Mr. TRUSZYNSKI. It is an internal political situation that has resulted in some localized military action. That situation sparked the disruption of communications.

However, our station is considerably removed from the center of town where these activities were taking place. There has been no disruption of the station activities locally at all, except for the communications.

Mr. BOLAND. Do you sense any anti-American feeling there?

Mr. TRUSZYNSKI. No. We have looked at this situation closely and it turns out that there has been no reaction against foreign personnel generally, and none at all against our own.

It is interesting to note that after the first day, when you have the normal reaction of families there, our own people have essentially gone back to business as usual. There is a daily curfew but that has not disrupted our activities.

SALVAGE VALUE OF MADAGASCAR STATION

Mr. TALCOTT. I would like to ask two follow-on questions.

What is the salvage value of our facility there? Where is the closest useful place that we could move it?

Mr. TRUSZYNSKI. We have been looking at this, obviously, as we always would in case things go from bad to worse, which I think is currently an unlikely possibility.

First of all, should we be invited out, we would remove the equipment for use elsewhere in the network. It is certainly usable in that regard.

We would look at how we might provide support through a greater use of our tracking ship and tracking aircraft for very specific launch support activities and probably proceed in that way.

Mr. TALCOTT. But if the political situation in Madagascar deteriorates, can we salvage something?

Mr. TRUSZYNSKI. Yes; indeed we would.

Mr. TALCOTT. Thank you.

TECHNOLOGY UTILIZATION

Mr. ROUSH. Thank you very much, Mr. Truszynski.

Now, could someone bring us up to date on what is happening insofar as technology utilization is concerned? Give us some interesting examples of how we are making use of this knowledge.

Dr. FLETCHER. The witness is Mr. E. Z. Gray, who has appeared before.

Mr. GRAY. Mr. Chairman, as far as progress is concerned, I am pleased to report that, as you are aware, we publish 300 to 400 technical briefs, summaries of our innovations each year. We now have published more than 6,000 technical briefs. To illustrate the response to these summaries, which we call "Tech Briefs," we put out a tech brief on solar heating of homes, and we received 4,000 inquiries on that item alone. That example gives some idea of the range of our technology dissemination and the interest in the program.

As you are also aware, we have NASA-sponsored industrial applications centers, which interact with all types of companies. We have one in the State of Indiana that you are familiar with. The number of clients has increased by over 30 percent in the last year. We also had about a 50-percent increase in the income from these clients to the application centers.

Therefore, through an aggressive program, we are able to reach out and transfer our technology to more industrial firms than we have ever had before.

NASA'S INDUSTRIAL APPLICATIONS CENTERS

Mr. ROUSH. Do these various centers follow the same pattern as is followed at Indiana University with industry participating financially as well as in the receipt of information?

Mr. GRAY. Yes, Mr. Roush, the pattern is exactly the same.

Mr. ROUSH. Does that financial participation vary from industry to industry depending on the size of the industry?

Mr. GRAY. Yes, it does. Small businesses receive the service for under $150 in order that we can help transfer the technology to a broad sector of this community.

Mr. ROUSH. What is the most they receive from any one industry, or do you know?

Mr. GRAY. As I recall, it is around $5,000 to $10,000.

Mr. ROUSH. I was going to suggest that it was around $5,000.

Mr. GRAY. Yes.

GROWTH OF PARTICIPANTS

Mr. ROUSH. Has the number of participants in these programs grown or diminished?

Mr. GRAY. It is definitely growing. As I mentioned, the number of firms participating increased by 30 percent during the last year. Over the past 5 years, it has increased by 800 percent. There is growing interest, and these industrial applications centers are doing good work.

TECHNOLOGY UTILIZATION REQUEST FOR FISCAL YEAR 1976

Mr. ROUSH. Mr. Chairman, I can remember the time when the authorization subcommittee voted to delete the $5 million for technology utilization. It took a struggle in the full authorization committee to restore that money.

I think that these funds for technology utilization are some of the best money that is spent. You are asking for an increase this year?

Mr. GRAY. Yes; we are requesting $7 million in fiscal year 1976, compared with $5.5 million in fiscal year 1975. The $1.5 million increase will allow us to do an even better job.

One of the factors, we find, is that the number of clients is geographically limited. They are clustered around areas where we have the centers. Since we only have six centers in the United States, and the number of clients we serve is less than 1 percent of the industrial firms, we think there is a lot of room for growth.

Mr. BOLAND. Where are the centers?

Mr. GRAY. These centers are located in Connecticut, Pennsylvania, North Carolina, New Mexico, California, and——

Mr. ROUSH. Do not forget Indiana.

Mr. GRAY [continuing]. And Indiana.

CONGRESSIONAL OFFICE OF TECHNOLOGY ASSESSMENT

Mr. ROUSH. Does your office have any relationship with the Office of Technology Assessment, which has become the arm of the Congress in this regard? Don't you have some relationship with them, Dr. Fletcher?

Dr. FLETCHER. NASA does.

Mr. ROUSH. Doesn't your technology utilization office have some relationship with them?

Dr. FLETCHER. We coordinate with the Office of Technology Assessment at frequent intervals. In fact, in the early days we provided consulting advice. I might add that my former secretary now works for the Director of OTA, Mr. Daddario; so we have very close associations with that Office.

EXAMPLES OF TECHNOLOGY TRANSFERS

Mr. ROUSH. Could you give us some examples of technology transfer or utilization? One of our challenges is trying to convey an understanding of the research and development program, the results of which are not necessarily seen immediately. Perhaps you could now give us a few examples, and then, as you did last year, supply for the record a more detailed description of examples. People should know what returns are coming out of NASA-developed technology.

Could you do that?

RECHARGEABLE PACEMAKER

Mr. GRAY. Yes. Last year we mentioned that we were involved with a rechargeable cardiac pacemaker with the Johns Hopkins University. At that time, they had just done the first implant. At the present time, they have done more than 1,500 of these implants, and they have all been very successful and, to the best of our knowledge, there has not been a single failure of that particular pacemaker.

Mr. ROUSH. Is this the rechargeable instrument?

Mr. GRAY. Yes; it is.

Mr. ROUSH. It is charged by wrapping a device around the person?

Mr. GRAY. That is correct.

Dr. FLETCHER. We call it a vest, Mr. Chairman.

Mr. ROUSH. A vest is worn by the person while the pacemaker is recharged?

Mr. GRAY. Yes, sir. Once the pacemaker is implanted, it will last at least 20 years so it eliminates the expense and discomfort of going back for surgical replacement of batteries, which occurs with a nonrechargeable pacemaker.

Mr. ROUSH. How often does that occur?

Mr. GRAY. Originally it was about every 2 years. Now I think they have extended the lifetime of nonrechargeable ones to between 3 and 5 years.

FLAT WIRE CABLING APPLICATIONS

Mr. ROUSH. Do you have other examples?

Mr. GRAY. Yes, sir. The flat wire cabling, which we developed for Apollo and Skylab, has now been installed in six apartments located in the State of New York. It has also been installed by the Western Electric Co. in three Bell System offices. They have estimated that they have saved about $2 a square foot by the fact that they are able to install the flat wire cabling on the surface as opposed to having to install duct work under the floors and through the joists and the upright partitions.

FIREFIGHTERS' BREATHING APPARATUS

We also have an improved firefighters' breathing apparatus which is now being used in three cities: New York City, Houston, and Los Angeles. This is a lightweight firefighters' breathing unit, which is 50-percent lighter than the old system. As a result, the firefighters can carry out their work more easily and more safely.

This firefighters' breathing apparatus has been used in actual firefighting in the three cities I mentioned. They are very pleased with the development of that system. A commercial version is expected to be available this fall.

Dr. FLETCHER. Mr. Chairman, I noticed in the newspaper that one of the problems in fighting the fire in a telephone building in New York was the fact that they ran out of oxygen.

There are two sizes of oxygen containers in the improved firefighting breathing apparatus that came out of NASA technology. One is a large size and the other is a smaller size. If they ordered the large size and had enough units, the problem would not have occurred.

Mr. GRAY. They only had five units.

Dr. FLETCHER. If enough units and associated oxygen supply were available, they might have stopped the fire much sooner.

SPINOFFS FROM APOLLO

Mr. ROUSH. Dr. Schmitt, to your knowledge, has any of the instrumentation or technology that you used on your Apollo 17 mission to the Moon found practical usage?

Dr. SCHMITT. In a very real way, the firefighting equipment does come out of the development of the portable life support system, and also the efforts at Cape Kennedy to provide for fire protection and firefighting on the pad, if I am not mistaken.

Mr. GRAY. That is correct.

Dr. SCHMITT. I think the real potential of what we used on the Moon is still about 5 to 10 years away from transfer.

We now have underway for the Department of the Interior a program for enhancement of mine safety and advancement of coal extraction technology. We are, at the request of theDepartment of the Interior, examining the technology gained from the manned space flight programs to see how it could be applied to achieve major innovations in mine safety and coal extraction.

Dr. Low. The flat wire conductor cabling which Mr. Gray mentioned actually was used by Dr. Schmitt on the Moon.

Dr. SCHMITT. We used that extensively in the experiments for the Apollo lunar surface scientific package. You may recall that the astronauts distributed this cabling during the extravehicular activity on the Moon's surface. It was one such cable that John Young unfortunately tripped on in the Apollo 16 mission, but that was a risk that we had to take on the Moon. In a spacesuit, you can't always see where your feet are, but that is exactly the same kind of cable.

REMOTE HEALTH CARE SERVICES

Dr. Low. Another example of returns from space technology is the remote health care systems that are being used by fire departments throughout the country. These systems are based entirely on the medical instrumentation which we used in flights such as Apollo and Skylab.

OFFSHORE OIL WELLS

Dr. SCHMITT. I can also think of a spinoff that I heard from a gentleman who manufactures pressure transducers. They are using the pressure transducer technology which was developed for the Saturn V launch vehicle for the monitoring of offshore oil wells to measure the pressure levels.

There is a very broad utilization of the technology developed by NASA, much of which we aren't aware of because very often we don't hear about the transfer.

AIRPORT BAGGAGE CHECKOUT

Dr. PETRONE. We had an X-ray instrument developed by American Science & Engineering. This was to survey the Moon remotely. That company has converted this instrument into a portable device used in our airports to help expedite the checking of passengers' carry-on baggage. They directly attribute that detection device to the work they did in developing the X-ray spectrometer for the Apollo spacecraft. It is that valuable type of interaction and development that leads to new products and applications.

We now have this X-ray device which can quickly clear bags through the airport checkout counters. And the company that is making that device is the one that got started in that business, by developing X-ray spectrometers for remote sensing of the Moon.

Mr. ROUSH. Is that the device that will also clear your film of any images you may already have on it?

Dr. PETRONE. It depends on the level. The level of X-ray being used there has been kept low and it is not dangerous. Film is a different story, but in terms of people being affected, there is no problem.

NEED TO IDENTIFY FULL RANGE OF NASA BENEFITS

Mr. TALCOTT. I think what Dr. Schmitt said is very important. We can catalog all of these transfers and search through our files and find all of these spectacular benefits, but there is probably an unlimited number of applications that we don't even know or hear about. You find it out almost by accident. We need to document all these benefits.

Mr. GRAY. Mr. Talcott, we have a very aggressive program underway to do just that. We are in the process of compiling the data in a document called "NASA Benefits." We intend to do even a more aggressive job to document them, so that a report can be made available. It is, of course, a sizable task to do this documentation.

Dr. PETRONE. So far, we have only scratched the surface.

Dr. FLETCHER. I would say that we have really only begun to identify the enormous range of benefits gained from NASA-developed technology.

Mr. TALCOTT. Our committee had to struggle with you people for years to try to get you to tell us some of the areas where there was this transfer and where there was this Earth application so we could just sell the program to our colleagues.

Now we are finally getting to the point where all of the people of the Earth can find out how they are benefiting from this very small research program.

Mr. GRAY. That is correct.

IMAGE ENHANCEMENT TECHNOLOGY

Dr. SCHMITT. Could I make one, I think very significant, statement that just occurred to me? I have been so involved in it that I tend to forget to mention it. In the course of the development of an active seismic experiment for the Moon, we had to produce very low-noise electronic equipment for the geophones. That is what senses an energy signal put into the surface with an explosive charge. That technology of extremely low-noise geaphones plus the rest of the sensor system that goes with them, is now one of the major reasons that we can directly sense, in many favorable cases, hydrocarbons under the Earth.

That has been the so-called bright-spot technology. Amplitude-enhancement technology is in a very large measure a direct outgrowth of the development in those particular sensors, along with the NASA technology for image enhancement which comes out of our applications programs. These techniques, in turn, came out of lunar and planetary photography. How do you get the most out of an image? Image enhancement makes this bright-spot technology possible.

Mr. ROUSH. This computer enhancement program, as I recall, came from the pictures of Surveyor?

Dr. SCHMITT. Yes, sir, it started with Surveyor.

Mr. ROUSH. It is now being used in the field of X-rays.

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Dr. SCHMITT. That is correct, Mr. Chairman.

Mr. ROUSH. That is my understanding.

Dr. SCHMITT. Actually I think the first real application was probably the Ranger photography, if I remember correctly, where they were trying to get all the noise out of it if they could. It is now much more sophisticated. The Jupiter and Venus pictures are all enhanced in that way, in addition to the work done with the Landsat applications satellites.

EXAMPLES OF TECHNOLOGY UTILIZATION

Mr. ROUSH. If you could supply for the record as you did last year some of these examples, it would be very helpful.

Dr. FLETCHER. Mr. Chairman, we will give you a list of the items that are in that book, but I would hate it to be thought of as a very comprehensive list.

Mr. GRAY. It is a start.

Dr. FLETCHER. The first four things which I asked about which I knew personally came out of the space program were not in that list.

Mr. ROUSH. I think it would be helpful to the members.

Mr. GRAY. We will give you a version.

Mr. ROUSH. We are asked to give speeches and discuss these matters with our constituents and with our colleagues. I think it would be helpful if we did have that information.

[The information follows:]

NASA's structural analysis computer program (Nastran).—Nastran is a general-purpose digital computer program that was developed by NASA to analyze the elastic behavior of aircraft and space vehicles. The program was of significant use in the analysis of the Saturn rocket and in the design of the Space Shuttle. Through a continuing maintenance and updating program, NASA has made this technique available to public sector users for shipbuilding, transportation, powerplant design and architecture. The Ford Motor Co. has been using the program since 1971 for design analysis of automobile, truck, and farm-tractor components and have realized significant in R. & D. time and development testing costs. Other examples of economically significant uses of this program include the design of nuclear powerplants, the dynamic modeling of high temperature gas-cooled reactors, the design of ruggedized railroad cars, and the design of many geodesic and high-rise structures.

Pavement grooving.—A concept, originated in England, concerned with pavement grooving to facilitate water runoff has been thoroughly researched and tested by NASA under the auspices of its aeronautics program to reduce airplane skidding on wet runways. The techniques developed by NASA have proved to be highly successful in improving contact between the tire and surface and significantly reduces hydroplaning. Thus far, upward of 50 runways have been grooved at major airports of a number of U.S. cities. In addition, the technique has been used in over 25 States for grooving dangerous highway sections and has been shown to significantly reduce the incidence of highway accidents caused by wet pavements. The results of this research has resulted in the formation of a new industry with over $2 million annual business.

Flat-conductor-cable wiring.—Flat-conductor-cable technology was developed by NASA for use in aircraft and spacecraft electrical systems primarily because of weight and space restrictions. Because of the rising cost of installing electrical systems in new and renovated buildings, NASA has supported the conceptual design and protoype hardware development to adapt this technology to commerical applications. The effort has proven the feasibility of using flat conductor cable electrical systems for both industrial and residental applications. Although there are many obstacles to be overcome concerning basic electrical standards,

many industrial organizations and governmental agencies have shown considerable interest in the technology and it is felt significant construction cost reductions are achievable using the technology.

High purity carbon implants.—The technology developed by NASA to provide high-purity, high-strength carbon for use on space capsule heat shields and rocket engine linings has resulted in a new concept in implantable prosthetic devices. As a result of NASA supported research at the Rancho Los Amigos Hospital, a whole new concept in the direct skeletal attachment of a limb prosthesis has been developed. The physiologically compatible aspects of this research now makes it possible to provide artificial skeletal support for amputees rather than current suspension and socket devices. Also, the permanent implantation of percutaneous connectors to relieve pain and relieve involuntary muscle contractions by electrical stimulation has obvious functional, psychological and vocational advantages.

Heat pipe technology.—Because of the strigent requirements to provide reliable, effective devices for thermal conductivity on spacecraft, NASA has sponsored significant developments in the state-of-the-art of heat pipe technology that has since been adapted for commercial applications. Probably the most significant application is the use of this technology to prevent thawing of permafrost under structures in the far north. Heat pipes called cryo-anchors will be used to maintain stability of the supporting structures of the Alaska pipelines. Upward of 110,000 units will be installed along a 310-mile segment of the 800-mile-long pipeline. Other applications of this technology resulting in a multimillion dollar business includes the recovery of heat from residential furnace flue gas, increasing the efficiency of industrial dryers, furnaces, etcetera.

Firefighters breathing system.—Technology developed by NASA under the Apollo program to provide for extravehicular life support systems has been adapted to provide improved firemen's breathing apparatus. NASA has supported the development of an open-circuit demand systems utilizing a light weight pressure vehicle. Prototype systems have been built and are being field tested in New York, Los Angeles, and Houston. The tests conducted thus far have proved so successful that a number of municipal fire departments have already purchased compatible air compressors in anticipation of this apparatus being commercially available in the near future.

Telecare.—The remote biomedical monitoring and treatment technology developed by NASA for the manned space flight program is used widely in emergency medical systems. Telecare, a completely self-contained, portable cardiac diagnostic, therapeutic, and communications system, developed in conjunction with NASA is used aboard ambulances and rescue vehicles. The suitcase-size telecare unit weighing approximately 40 pounds is easily carried to a patient's side by an emergency medical technician. The use of telecare enables the physician in the hospital to evaluate the patient's electrocardiogram in real time and to relay instructions. The city of Houston has credited telecare as one of the factors in reducing the traffic fatality rate despite an increase in the total number of major accidents.

Atmospheric pollution monitoring.—Techniques developed under NASA's aeronautics program using laser-radar (LIDAR) for measuring haze particles in the lower atmosphere and to detect clear-air turbulence have been used to provide reliable air pollution data. Using modified LIDAR systems, NASA has worked with the California Air Resources Board to determine the vertical distribution of finely suspended particles near the ground and with the Virginia State Air Pollution Control Board to determine air quality at various locations throughout the State. In addition, NASA is supporting the development of a compact, portable laser-radar system, based on the LIDAR techniques, which will serve to expand the usefulness of this successful technique for monitoring atmospheric pollution.

Image enhancement.—Computer image processing, which involves the amalgamation of television and computer technologies, was developed by NASA to improve the intelligibility of space photography. Under NASA's sponsorship this technology has been used in a broad range of applications including the earlier diagnosis of burn depths thereby facilitating early treatment, the effective monitoring of pollution in bodies of water, the medical interpretation of X-rays particularly in the more precise detection of heart disease, and to provide geophysical

data for defining potential mineral-deposit areas. NASA is not only developing the techniques for using this technology but is also widely disseminating the information obtained and training others in its use.

Computerized bridge safety inspection.—A system developed by NASA for analyzing, by computer, the structural flutter fatigue in wind tunnel model aircraft has been used to detect structural deterioration in bridges. The technique, called randomdec, is currently being effectively used to detect structural fatigue in aircraft and rocket components. A highway bridge in California has been equipped with sensors to monitor the vibrations from traffic and the effects of weather. The preliminary results are promising enough to warrant further research and NASA and the Federal Highway Administration are working together to further verify the feasibility of the technique.

Liquefied natural gas safety.—NASA's experience in handling volatile rocket fuels is being applied to the safe handling and storage of liquefied natural gas (LNG). LNG is increasingly being used for heating and lighting fuel and the necessity for storing this material near coastal-urban centers is growing in magnitude. As a result, NASA is currently sponsoring programs aimed at helping State and local governments to cope with the problems involved. These programs include: The development of a risk management system for all phases of design, construction, operation and maintenance of LNG and other technically advanced facilities; the development of an LNG safety manual; and the development of a model regarding LNG spills on water to assess LNG vaporization and spreading which can lead to situation control. At the present time, a prototype risk management technique is being used by the New York City Fire Department in following LNG plant design and development. Because of the widespread need for the information to be derived from these programs, NASA will disseminate the results of this research to all interested State and local governments.

Biological isolation garment.—A garment derived from the design used to biologically isolate Apollo astronauts quarantined on their return to Earth from the lunar mission, is providing a portable, sterile environment for cancer patients undergoing chemotherapy. The Apollo biological-isolation garment was adapted for cancer patients as an extension of the pioneering use by the National Cancer Institute, of cleanroom techniques to provide a sterile environment for patients. The garment, which proved an overwhelming success, allowed the patient to wear it frequently. The patient can leave the room for recreation with other members of his family as well as to travel about the hospital for tests and therapy.

Hand physiotherapy assist device.—A new technique for providing physiotherapy to the seriously injured hand has been developed by NASA in collaboration with the North Carolina Memorial Hospital's Hand Rehabilitation Center. By taking advantage of the expertise obtained in the design of space suits and using NASA-developed temper foam, a physiotherapy assist device was developed and clinically tested at the Hand Rehabilitation Center. The results were so promising that widespread use of the innovation is anticipated and a well established firm in the rehabilitatin field has expressed a desire to manufacture and market the device.

Railroad tank car fire protection.—NASA and the Federal Railroad Administration are cooperating in a project to provide rupture protection to rail tank cars carrying flammable liquids. When such cars are exposed to fire they often rupture, causing loss of life, as well as expensive property damage. NASA has conducted considerable research and development in the thermal protection of structure, such as aircraft, and it is felt that similar techniques could be employed for the fire protection of railroad tank cars. An instrumented tank car was set on fire and the data obtained during this realistic test was analyzed. Currently, the various fire environments are being analyzed, and fire testing facilities which duplicate these environments and permit realistic thermal shield protection assessment are behind designed. This will allow selection of fire protection materials which will prevent the catastrophic rupture of railroad tank cars.

Composite leg brace material.—NASA scientists and engineers have built a leg brace of lightweight graphite epoxy composite material to replace the present orthopedic leg and pelvic braces, which are too heavy and impair the move-

ments of the patient. The conventional braces are constructed of steel, aluminum, leather, wood blocks, and some form of padding. If the weight of these component materials could be reduced, the brace would be more useful. The composite material used in this one-of-a-kind brace was originally developed to fabricate high-strength, low-weight structural members for spacecraft. The initial evaluation of the brace resulted in some valuable suggestions which encouraged the NASA team to design and fabricate second and third generation braces, and to modiy the first brace. One of the most important design considerations was to make the fabrication of the lightweight brace as simple as possible, as a complex fabrication technique would complicate the future widespread use of the lighter weight brace materials. These design improvements hold the promise that a simply made and clinically useful lightweight brace can be developed for economical widespread use. The NASA team is also investigating materials and technologies for use in improving the characteristics of the nonmetal brace components.

Horizontal shower.—A NASA designed shower which was initially used to bathe subjects in long-term bed-rest studies who had to remain absolutely horizontal to stimulate the effects of zero gravity which would be encountered in long space flights is being adapted for bathing bedridden patients. Conventionally, the thorough bathing of physically incapacitated patients is quite difficult, yet a complete cleansing and refreshing bath has considerable therapeutic value for the patient. In addition, great care must be exercised when moving these patients to preclude additional discomfort while providing a thorough bath. Horizontal showers based on the NASA design are being manufactured by Diamondhead Industries and General Teleoperators, Inc. The initial production units are being evaluated at the Stanford Medical Center and the Palo Alto Veterans' Administration Hospital. The many advantages of the system should make it quite attractive for use in hospitals, rehabilitation centers, and chronic care facilities.

Solar energy heating and cooling.—Prompted by the concern about the "energy crisis" in the Nation, NASA sponsored a feasibility study of solar-powered systems for space heating, air-conditioning, and hot water heating in residential applications. The study report, which describes the major components, optimum configuration, and an economic and technical analysis of working fluids, was widely distributed via the NASA technology utilization's publication and dissemination program. As a result, a number of industrial organizations are using this study for the design and prototype development of solar water heaters, the collection and storage of solar energy during "peak" hours for use in heating and cooling systems, and for economically heating swimming pools.

Electric power dispatch computers.—The Apollo program requirements for computer checkout and control systems caused major advances in computer systems technology. The "executive program" portion of the Apollo Guidance Computer, which allots computer time among various jobs according to a priority schedule, was used to develop TRW controls "executive program" which is now standard in the company's larger monitoring and control systems. The computer system has been installed in three major electrical transmission plants and is being installed in another. The real-time control capabilities of the systems are credited with decreasing blackout incidences and in saving hundreds of thousands of dollars in annual transmission costs.

Rechargeable cardiac pacemaker.—A rechargeable cardiac pacemaker, powered by nickel-cadmium batteries originally used for NASA spacecraft power systems, has been developed by the Johns Hopkins Applied Physics Laboratory and is now commercially available. This pacemaker, which is recharged conveniently and comfortably once a week, remains implanted in the heart patient for at least 10 years as contrasted with conventional mercury cell powered pacemakers that must be surgically replaced every 2 years. This reduction in surgical risk and cost to the patients is particularly important. As of the end of 1974, 1,200 successful implants of this rechargeable pacemaker have been accomplished.

TECHNOLOGY UTILIZATION PERSONNEL

Mr. BOLAND. What is the total number of personnel involved in the technology utilization program?

Mr. GRAY. Within NASA?

Mr. BOLAND. Yes.

Mr. GRAY. In fiscal year 1975, there are 72 permanent civil service positions.

Mr. ROUSH. Dr. Fletcher, you and your people have been very helpful and responsive, and we are grateful for the information you have imparted.

Mr. Chairman, do you have anything else?

The committee stands adjourned until tomorrow morning.

THURSDAY, MARCH 6, 1975.

CONSTRUCTION OF FACILITIES

Mr. TRAXLER. The committee will come to order.

We are starting this morning with volume II, the fiscal year 1976 construction of facilities budget estimates. We will place pages SUM 1 through CF 7–13 in the record at this point and refer to them as we review the projects.

[The pages follow:]

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

GENERAL STATEMENT

This appropriation provides for contractual services for the design, major rehabilitation, and modification of facilities; the construction of new facilities; minor construction; the purchase of related equipment and advanced design related to facilities planned for future authorization.

The program for 1976, in many aspects, reflects a continuation of prior years' endeavors, especially in regard to:

a. Space shuttle facilities

b. Facility rehabilitation and modification and minor construction programs

c. Facility planning and design.

As has been forecast, FY 1976 space shuttle facility requirements are less than the amounts approved for FY 1975 and FY 1974. These requirements for unique shuttle facilities are time sensitive and are to meet specific milestones established for the first horizontal and manned orbital flights.

Each of the non-shuttle discrete facility projects requested for FY 1976 represent a specific need in support of: (1) Scientific Investigations in Space, (2) Aeronautical Research and Technology, and (3) Supporting Activities.

The FY 1976 Rehabilitation and Modification of Facilities program continues the objective of preserving and enhancing the utilization of existing facilities. This is a most effective program in terms of results achieved and essential in light of the extensive amount of work of this nature yet to be undertaken. The inclusion of foreseeable programmatic facility projects is more evident this year, reflecting the relative increased urgency of these requirements. The Minor Construction program is largely programmatic as in the past, either directly or as indirect program support, and is also an essential program providing the means to accomplish the smaller facility projects of this type.

The FY 1976 request for Facility Planning and Design funds reflects the future years redirection in forecasting space shuttle facility requirements.

The request for FY 1976 is $84,620,000, a decrease of $55,535,000 under the amount appropriated for FY 1975. Outlays are estimated to be $108,100,000 in FY 1976, an increase of $8,100,000 over the estimate for FY 1975.

An additional amount of $14,500,000 is requested to continue Rehabilitation and Modifications, Minor Construction and Facility Planning and Design during the transition period from July 1, 1976 through September 30, 1976.

PROPOSED APPROPRIATION LANGUAGE

Construction of Facilities

[For advance planning, design, rehabilitation, modification and construction of facilities for the National Aeronautics and Space Administration, and for the acquisition or condemnation of real property, as authorized by law, $140,155,000 including (1) $3,660,000 for addition to flight and guidance simulation laboratory, Ames Research Center; (2) $890,000 for rehabilitation and modification of science and applications laboratories, Goddard Space Flight Center; (3) $1,220,000 for modifications for fire protection and safety, Goddard Space Flight Center; (4) $150,000 for acquisition of land, Jet Propulsion Laboratory; (5) $3,790,000 for addition for integrated systems testing facility, Jet Propulsion Laboratory; (6) $935,000 for modification of water supply system, Lyndon B. Johnson Space Center; (7) $515,000 for modification of 6,000 p.s.i. air storage system, Langley Research Center; (8) $2,990,000 for rehabilitation of 16-foot transonic wind tunnel, Langley Research Center; (9) $2,580,000 for modification of propulsion systems laboratory, Lewis Research Center; (10) $660,000 for modification of rocket engine test facility, Lewis Research Center; (11) $4,060,000 for construction of X-ray telescope facility, Marshall Space Flight Center; (12) $1,370,000 for modification of beach protection system, Wallops Station; (13) $6,040,000 for construction of infrared telescope facility, Mauna Kea, Hawaii; (14) $1,430,000 for modifications for fire protection and safety at various tracking and data stations; (15) $77,020,000 for Space Shuttle facilities at various locations, as follows: (A) modification of the vibration and acoustic test facility, Lyndon B. Johnson Space Center, (B) modifications for crew training facilities, Lyndon B. Johnson Space Center, (C) construction of materials test facility, White Sands Test Facility, (D) modifications for dynamic test facilities, Marshall Space Flight Center, and NASA Industrial Plant, Downey, California, (E) modifications for solid rocket booster structural test facilities, Marshall Space Flight Center, (F) construction of Orbiter landing facilities, John F. Kennedy Space Center, (G) construction of Orbiter processing facility, John F. Kennedy Space Center, (H) modifications to launch complex 39, John F. Kennedy Space Center, (I) $1,940,000 for construction of an Orbiter Horizontal Flight Test Facility, Flight Research Center; (16) $14,900,000 for minor rehabilitation and modification of facilities at various locations; (17) $4,500,000 for minor construction of new facilities and additions to existing facilities at various locations; (18) $10,900,000 for facility planning and design not otherwise provided for; and (19) $4,880,000 for an addition to the Systems Development Laboratory (SDL) at the Jet Propulsion Laboratory (JPL); to remain available for obligation until June 30, 1977: *Provided*, That, notwithstanding the limitation on the availability of funds appropriated under this head by this appropriation act, and except with respect to items (16) through (18) above, when any activity, for which appropriations under this head made by this act are available, has been initiated by the incurrence of obligations therefor, the amount available for such activity shall remain available until expended.] *For construction, 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, $84,620,000, to remain available for obligation until September 30, 1978: 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 rehabilitation and modification of facilities, minor construction of new facilities and additions to existing facilities, and facility planning and design.*

For "Construction of facilities," to be available July 1, 1976, $14,500,000, to remain available for obligation until September 30, 1979. (42 U.S.C. 2461, et seq.; Department of Housing and Urban Development; Space, Science, Veterans, and Certain Other Independent Agencies Appropriation Act, 1975; additional authorizing legislation to be proposed for fiscal year 1976, and for the period beginning July 1, 1976.)

Program and Financing (in thousands of dollars)

Identification code 27-00-0107-0-1-999	Budget plan (amounts for construction of facilities actions programed)			Costs and obligations		
	1974 actual	1975 estimate	1976 estimate	1974 actual	1975 estimate	1976 estimate
Program by activities:						
1. Manned space flight	56,300	77,185	47,220	30,244	61,200	71,000
2. Scientific investigations in space	2,030	18,770	2,490	11,883	7,900	8,600
R Space applications	980			1,027		
4. Space research and technology		660		151	200	200
5. Aeronautical research and technology	2,410	9,745	4,635	7,775	7,600	5,200
7. Supporting activities	39,380	36,295	30,275	26,208	35,100	28,000
Total program costs, funded	101,100	142,655	84,620	77,288	112,000	113,000
Change in selected resources (undelivered orders)				21,068	42,000	−8,500
10 Total	101,100	142,655	84,620	98,356	154,000	104,500
Financing:						
21 Unobligated balance available, start of year, for completion of prior year budget plans				−73,997	−76,734	−65,389
24 Unobligated balance available, end of year, for completion of prior year budget plans				76,734	65,389	45,509
25 Unobligated balance lapsing				7		
Budget authority	101,100	142,655	84,620	101,100	142,655	84,620
Budget authority:						
40 Appropriation	101,100	140,155	84,620	101,100	140,155	84,620
42 Transferred from other accounts		2,500			2,500	
43 Appropriation (adjusted)	101,100	142,655	84,620	101,100	142,655	84,620
Relation of obligations to outlays:						
71 Obligations incurred, net				98,356	154,000	104,500
72 Obligated balance, start of year				68,203	91,432	145,432
74 Obligated balance, end of year				−91,432	−145,432	−141,832
90 Outlays				75,127	100,000	108,100

Note.—Reconciliation of budget plan to obligations:	*1974 actual*	*1975 estimate*	*1976 estimate*
Total budget plan	101,100	142,655	84,620
Deduct portion of budget plan to be obligated in subsequent years	36,975	31,755	16,620
Add obligations of prior year budget plans	34,231	43,100	36,500
Total obligations	98,356	154,000	104,500

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

SUMMARY OF THE BUDGET PLAN BY LOCATION

Location	Fiscal Year 1974	Fiscal Year 1975	Fiscal Year 1976	Transition Period
Ames Research Center....	---	$3,660,000	$2,695,000	---
Goddard Space Flight Center.....	$1,403,000	2,110,000	---	---
Jet Propulsion Laboratory.....	1,320,000	8,820,000	---	---
Johnson Space Center....	---	935,000	2,490,000	---
Langley Research Center.	4,030,000	3,505,000	1,940,000	---
Lewis Research Center...	---	3,240,000	---	---
Marshall Space Flight Center.....	---	4,060,000	---	---
Wallops Flight Center...	1,112,000	1,370,000	---	---
Various Locations.....	3,950,000	7,470,000	---	---
Space Shuttle Facilities	56,300,000	77,185,000	47,220,000	---
Rehabilitation and Modification.....	14,785,000	14,900,000	16,000,000	$8,750,000
Minor Construction.....	4,600,000	4,500,000	5,000,000	2,950,000
Facility Planning and Design.....	13,600,000	10,900,000	9,275,000	2,800,000
Total Plan.....	$101,100,000	$142,655,000	$84,620,000	$14,500,000

SUMMARY OF THE BUDGET PLAN BY PROGRAM OFFICE

Office of Manned Space Flight.....	$57,385,000	$78,120,000	$47,220,000	---
Office of Space Science.	4,815,000	22,400,000	2,490,000	---
Office of Aeronautics and Space Technology..	4,030,000	10,405,000	4,635,000	---
Office of Tracking and Data Acquisition.....	1,885,000	1,430,000	---	---
NASA Comptroller.....	32,985,000	30,300,000	30,275,000	$14,500,000
Total Plan.....	$101,100,000	$142,655,000	$84,620,000	$14,500,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

BUDGET PLAN BY LOCATION AND PROJECT

Prog Off		(Thousands of Dollars) FY 1974	FY 1975	FY 1976	Transition Period
	Ames Research Center	---	$3,660	$2,695	---
AST	Modification of 11-by 11-foot transonic wind tunnel.....	---	---	2,695	---
AST	Addition to flight and guidance simulation laboratory.....	---	3,660	---	---
	Goddard Space Flight Center	$1,403	2,110	---	---
SS	Rehabilitation and modification of science and applications laboratories	---	890	---	---
SS	Modifications for fire protection and safety....	---	1,220	---	---
SS	Replacement of transportation facility..	693	---	---	---
SS	Rehabilitation of vibrations facility.....	710	---	---	---
	Jet Propulsion Laboratory	1,320	8,820	---	---
SS	Acquisition of land.....	---	150	---	---
SS	Addition to systems development labotatory (SDL)....	---	4,880	---	---
SS	Addition for integrated systems testing facility.	---	3,790	---	---
SS	Modification of and addition to 25-foot space simulator building.....	740	---	---	---
SS	Modification of planetary mission support facilities.....	580	---	---	---

Prog Off		(Thousands of Dollars) FY 1974	FY 1975	FY 1976	Transition Period
	Johnson Space Center	---	$935	$2,490	---
SS	Addition to lunar sample curatorial facility.....	---	---	2,490	---
MSF	Modification of water supply system.....	---	935	---	---
	Langley Research Center	$4,030	3,505	1,940	---
AST	Addition for composite model and metal finishing shops.....	---	---	1,940	---
AST	Modification of 6,000 p.s.i. air storage system.....	---	515	---	---
AST	Rehabilitation of 16-foot transonic wind tunnel....	---	2,990	---	---
AST	Rehabilitation and modification of 600 p.s.i. air supply system.....	2,410	---	---	---
AST	Construction of systems and engineering building.	1,620	---	---	---
	Lewis Research Center	---	3,240	---	---
AST	Modification of propulsion systems laboratory.....	---	2,580	---	---
AST	Modification of rocket engine test facility.....	---	660	---	---
	Marshall Space Flight Center	---	4,060	---	---
SS	Construction of X-ray telescope facility.....	---	4,060	---	---
	Wallops Flight Center	1,112	1,370	---	---
SS	Modification of beach protection system.....	---	1,370	---	---
SS	Rehabilitation of airfield pavement.....	599	---	---	---
SS	Rehabilitation of communications system.....	513	---	---	---

Prog Off		(Thousands of Dollars) FY 1974	FY 1975	FY 1976	Transition Period
	Various Locations	$3,950	$7,470	---	---
SS	Construction of infrared telescope facility.....	---	6,040	---	---
TDA	Modifications for fire protection and safety at various tracking stations.	1,885	1,430	---	---
SS	Modification of space launch complex 2 West, Vandenberg Air Force Base.....	980	---	---	---
MSF	Modification of power system, Slidell Computer Complex.....	1,085	---	---	---
MSF	Space Shuttle Facilities	56,300	77,185	$47,220	---
	Modifications to launch complex 39 (KSC).....	---	35,355	13,110	---
	Construction of orbiter processing facility (KSC).	---	13,380	8,160	---
	Modifications for solid rocket booster processing facilities (KSC).....	---	---	5,240	---
	Modifications for hypergolic checkout and refurbishment facilities (KSC).....	---	---	6,940	---
	Modifications for launch equipment test facilities (KSC).....	---	---	1,960	---
	Construction of orbiter approach and landing test facilities (FRC, Calif. and Palmdale, Calif.)[1]/...	---	2,940	1,680	---
	Construction of shuttle/ carrier aircraft mating facilities (FRC, Calif. and Palmdale, Calif.).....	---	1,500	3,890	---
	Modifications for crew training facilities (JSC).	---	420	830	---
	Modification of the vibration and acoustic test facility (JSC).....	---	410	2,410	---

1/ Project identified in 1975 Authorization and Appropriation Acts as "Construction of Orbiter horizontal flight test facilities".

Prog Off		(Thousands of Dollars) FY 1974	FY 1975	FY 1976	Transition Period
	Space Shuttle Facilities (Cont'd)				
MSF	Modifications for solid rocket booster component manufacturing and assembly facilities (location to be designated).....	---	---	$3,000	---
	Construction of orbiter landing facilities (KSC).	$17,300	$15,880	---	---
	Modifications for dynamic test facilities (MSFC; Downey, Calif.).....	---	3,920	---	---
	Construction of materials test facility (WSTF).....	---	790	---	---
	Modifications for solid rocket booster structural test facilities (MSFC)...	---	2,590	---	---
	Modifications for auxiliary propulsion and power systems test facilities (WSTF).....	1,290	---	---	---
	Modifications for shuttle avionics integration laboratory (JSC).....	1,240	---	---	---
	Modifications for radiant heating verification facility (JSC).....	1,260	---	---	---
	Modifications for the orbiter propulsion system test facilities (MTF).....	11,300	---	---	---
	Modifications for external tank structural test facilities (MSFC).....	4,400	---	---	---
	Modification of manufacturing and subassembly facilities for the orbiter, NASA industrial plant, Downey, Calif.....	2,650	---	---	---

Prog Off		(Thousands of Dollars) FY 1974	FY 1975	FY 1976	Transition Period
MSF	Space Shuttle Facilities (Cont'd)				
	Modification of and addition to final assembly and checkout facilities for the orbiter, Air Force Plant #42, Palmdale, Calif.....	$7,350	---	---	---
	Modification of manufacturing and final assembly facilities for external tanks (MAF).....	9,510	---	---	---
COMP	Rehabilitation and Modification of Facilities at Various Locations	14,785	$14,900	$16,000	$8,750
COMP	Minor Construction of New Facilities and Additions to Existing Facilities at Various Locations	4,600	4,500	5,000	2,950
COMP	Facility Planning and Design	13,600	10,900	9,275	2,800
	TOTAL PLAN.....	$101,100	$142,655	$84,620	$14,500

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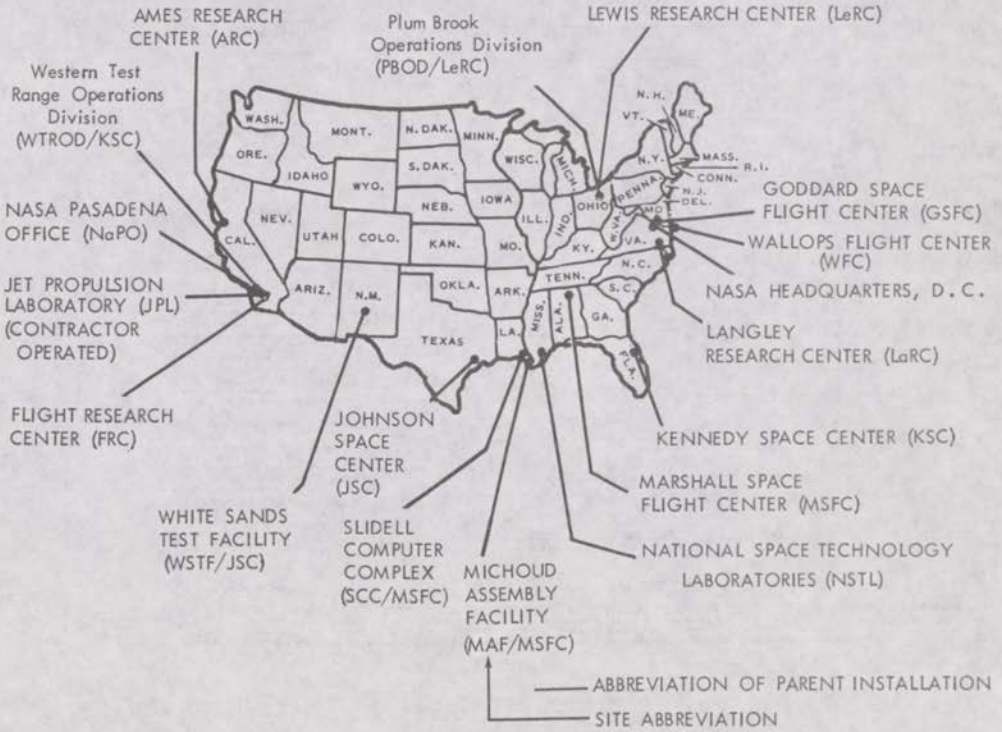
LOCATION OF NASA MAJOR AND COMPONENT INSTALLATIONS



SIM 11

RECORDED VALUE OF CAPITAL-TYPE PROPERTY
IN-HOUSE AND CONTRACTOR HELD
AS OF JUNE 30, 1974
(DOLLARS IN THOUSANDS)

Reporting Installation	Real Property					Equipment	(a) Fixed Assets in Progress	Grand Total
	Land	Buildings	Other Structures and Facilities	Leasehold Improvements	Total			
Ames Research Center	$ 2,928	$ 183,260	$ 4,496	$ -	$ 190,684	$ 110,276	$ 24,774	$ 325,732
ARC-Moffett Field, CA	2,928	183,260	4,496	-	190,684	105,995	24,774	321,453
Various Locations (b)	-	-	-	-	-	4,279	-	4,279
Flight Research Center	-	9,175	2,833	-	12,008	61,307	884	74,199
FRC-Edwards, CA	-	9,175	2,833	-	12,008	57,723	884	70,615
Various Locations (b)	-	-	-	-	-	3,584	-	3,584
Goddard Space Flight Center	1,661	92,607	62,067	172	156,507	555,188	12,562	724,257
GSFC-Greenbelt, MD	1,308	75,493	15,564	172	92,537	198,417	-	290,954
Tracking Stations (Two Networks)	353	17,113	46,458	-	63,924	288,127	12,562	364,613
Various Locations (b)	-	1	45	-	46	68,644	-	68,690
Jet Propulsion Laboratory	1,067	62,966	61,955	514	126,502	221,808	14,216	362,526
JPL - CA	1,067	53,651	8,179	514	63,411	138,750	14,216	216,377
Deep Space Network	-	9,315	53,776	-	63,091	83,558	-	146,649
Johnson Space Center	9,029	183,042	54,824	115	247,010	639,702	27,298	914,010
JSC - Houston, TX	5,459	149,289	32,050	27	186,825	342,822	27,298	556,945
White Sands Test Facility								
WSTF-Las Cruces, NM	-	8,690	17,780	-	26,470	36,438	-	62,908
Various Locations (b)	3,570	25,063	4,994	88	33,715	260,442	-	294,157
Kennedy Space Center	72,172	291,853	310,336	-	674,361	616,791	16,034	1,307,186
KSC - FL	72,172	291,853	310,336	-	674,361	249,298	15,895	939,554
Western Test Range Operations Div.								
WTR - Lompoc, CA	-	-	-	-	-	3,962	139	4,101
Various Locations (b)	-	-	-	-	-	363,531	-	363,531
Langley Research Center	116	127,837	153,628	-	281,581	146,062	40,486	468,129
LaRC - Hampton, VA	110	112,433	153,603	-	266,146	129,284	40,486	435,916
Various Locations (b)	6	15,404	25	-	15,435	36,778	-	52,213
Lewis Research Center	3,657	202,332	73,113	139	279,241	142,504	21,904	443,649
LeRC - Cleveland, OH	316	118,195	54,175	139	172,825	79,338	21,490	273,653
Plum Brook Operations Div.								
PBOD-Sandusky, OH	3,341	84,137	18,938	-	106,416	11,870	414	118,500
Various Locations (b)	-	-	-	-	-	51,496	-	51,496
Marshall Space Flight Center	7,568	193,595	103,552	3,288	308,003	485,165	27,035	820,203
MSFC - Huntsville, AL	-	115,080	52,618	-	167,698	245,759	6,828	420,285
Michoud Assembly Facility								
MAF - New Orleans, LA	7,505	66,046	26,682	-	100,233	57,263	519	158,015
Slidell Computer Complex								
SCC - Slidell, LA	63	4,492	879	-	5,434	20,400	-	25,834
Various Locations (b)	-	7,977	23,373	3,288	34,638	161,743	19,688	216,069
National Space Technology Laboratories	18,703	40,848	165,460	-	265,011	88,236	9,655	322,902
NSTL - Bay St. Louis, MS								
Wallops Flight Center	1,179	23,817	47,366	-	72,362	50,275	2,697	125,334
WFC - Wallops Island, VA	1,179	23,817	47,366	-	72,362	48,702	2,697	123,761
Various Locations (b)	-	-	-	-	-	1,573	-	1,573
NASA Headquarters	-	-	-	-	-	34,656	-	34,656
Washington, D.C.	-	-	-	-	-	2,429	-	2,429
Various Locations (b)	-	-	-	-	-	32,227	-	32,227
GRAND TOTAL	$ 118,080	$ 1,431,332	$ 1,039,630	$ 4,228	$ 2,593,270	$ 3,151,968	$ 197,345	$ 5,942,783

(a) Includes Contractor-Held Special Test Equipment ($707,199)
(b) Includes Capital Type Property in Possession of Contractors at Various Locations.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

PROJECT TITLE	Modification of 11- by 11- Foot Transonic Wind Tunnel
LOCATION	Ames Research Center
	FY 1976 CoF ESTIMATE $2,695,000

COGNIZANT INSTALLATION: Ames Research Center

LOCATION OF PROJECT: Moffett Field, Santa Clara County, California

COGNIZANT PROGRAM OFFICE: Office of Aeronautics and Space Technology

FY 1975 AND PRIOR YEARS CoF FUNDING:

Planning and Design	$170,000
Construction	11,420,000
Total FY 1975 and Prior Years	$11,590,000

SUMMARY PURPOSE AND SCOPE:

This project primarily involves the modification of the tunnel data acquisition system which will increase the operational efficiency of the 11 x 11-Foot (3.4 x 3.4m) Transonic Wind Tunnel and thus better accommodate requirements of the facility users. The modification of this transonic wind tunnel will provide for increased data acquisition speed, improved data system accuracy, increased reliability, and decreased maintenance. In addition, test "set up" time will be reduced. Monitoring and display of tunnel conditions and aerodynamic parameters will be provided on a "real time" basis as well as the capability to control certain wind tunnel operations.

This transonic test facility is a major element of the Ames "Unitary Wind Tunnel" which also encompasses two smaller supersonic test sections. The drive motors are common to all three test sections.

The proposed data system will include a data gathering system and a "real time" computer system with display and plotting equipment. Also, included in this project is the construction of a computer room to house the

data acquisition system, rehabilitation of the existing control room, and necessary repairs to the facility test chamber, Building N-227A.

PROJECT JUSTIFICATION:

Experimental investigations conducted in the 11-Foot (3.4m) Transonic Wind Tunnel include projects requested by: The Department of the Defense (DOD) relating to advanced aircraft and missiles; the aircraft industry relating to commercial transports testing for which the Government is reimbursed; in-house research organizations relating to advanced NASA programs; and other NASA Centers and Government organizations covering a broad range of advanced aircraft and aerospace projects. In response to such requests, this Unitary Plan Wind Tunnel (UPWT) facility is normally operated 24 hours per day, 6 days per week. During the past seven years, more than 60 percent of the available UPWT facility test occupancy hours have been utilized for investigations in the transonic test section. During the past five years, efforts to increase facility utilization and accommodate projects of high national importance and urgency have included weekend operations and test installations. In order to further relieve the especially heavy workload proposed for the 11-Foot (3.4m) tunnel, the 14-Foot (4.3m) Transonic Wind Tunnel has recently been reactivated to accommodate certain test work not requiring the high Reynolds number capability of the 11-Foot (3.4m) facility. With the present emphasis on aeronautics, especially in the transonic speed range, it is foreseen that the demand for experimental investigations in these transonic facilities will not only continue, but will probably increase.

The existing static data acquisition system and strain gage signal conditioning equipment can be properly described as being "mostly obsolete". Some necessary repair parts are no longer manufactured. Reliability is deteriorating and maintenance requirements are increasing and more time is required to achieve test objectives. Scheduling problems are also compounded particularly in the 11-Foot (3.4m) facility. The existing dynamic data acquisition system does not provide "on-line" data reduction, a feature essential to more safe and efficient conduct of certain wind tunnel investigations. The proposed data system modification will provide not only the necessary increased reliability and decreased maintenance, but will also provide improved data system accuracy, increased data acquisition speed, reduced test "set up" time, preliminary data reduction, and "real time" monitoring, thereby effectively increasing facility operational efficiency.

It is estimated that this increased operational efficiency would permit relatively the same test loading as is now being conducted within a given year and in addition will make available some added 600 occupancy hour capability. This estimated 600 occupancy hours is made up of about 350 hours from increased acquisition speed, some 50 hours from decreased maintenance and about 200 hours equally divided between reduced test set up time and improved monitoring. It is our present plan to move appropriate tests from the 14-Foot Transonic Wind Tunnel over to the 11-Foot to provide for a more efficient and effective overall operation in the 11-Foot Tunnel.

This will result in an overall annual savings of approximately $600,000 per year applicable to both tunnels of which approximately $440,000 relates directly to electrical power costs. Of course, this added capability can be translated into a capability to accomplish more priority testing of this approximate magnitude.

A new computer room is required to house the data acquisition computer. The proposed building rehabilitation includes the major items required to bring the facilities up to an acceptable and usable level.

PROJECT DESCRIPTION:

This modification project involves replacement of the present data acquisition system in the 11 x 11-Foot (3.4m x 3.4m) Transonic Wind Tunnel. The proposed replacement data system will consist of flexible high performance data gathering processor, a "real time" processor, and associated peripheral devices. Data gathering and real time monitoring of tunnel test progress will be provided. The data acquisition equipment, including necessary signal conditioning, under control of the data gathering processor, converts the tunnel analog data into continuous digital samples. This continuous stream of data is recorded on analog magnetic tape. The "real time" processor will provide control, continuous processing, and display of selected parameters such as lift and drag coefficients. Displays will be provided in the control room which will indicate these parameters in engineering units. These displayed data will then allow the test engineer to select those test conditions for which the entire complement of input data are to be recorded for subsequent processing. Upon command by the test engineer, the selected static and dynamic data are recorded in industry standard format on digital magnetic tapes as well as on magnetic discs. The magnetic discs are used for "real time" processing and for data editing.

As a function of data acquisition, the system will also verify that all input channels are functioning properly. Any channels which are inoperative or "out-of-limits" will initiate an error message to the operator.

Wind tunnel test "set up" will be accomplished by means of an "initialize" mode of operation. In this mode, the number and types of data channels will be assigned by the operator. This assignment will be made via a card deck and control switch settings. The operator will be allowed to alter the assignment during tunnel operation to accommodate equipment failures. Pre-run system checkout will also be provided by means of a checkout mode of operation. In this mode, the analog input channels are automatically stepped through known input voltages by the computer to verify operational status, amplifier gain and amplifier offset.

The proposed data system will be provided and installed as a "turn key" system by a single prime contractor. The design will use "off-the-shelf" modules where possible so as to reduce the total cost for special interfaces, design, installation, testing and training.

Enlargement and rehabilitation of the existing wind tunnel control room will be required to accommodate the new data system. The enlargement consists of construction of a computer room area below the existing control room. This computer room will be air conditioned and equipped with conditioned electrical power for the computer. Rehabilitation of the existing control room will include installation of additional air conditioning and electrical power for the additional control room equipment. The power conditioning equipment required for the proposed data system is included as a part of this project. Also included in this project is the rehabilitation of 11-Foot (3.4m) Transonic Wind Tunnel, Building N-227A, including elements such as rest room facilities, interior partitions, roof, and the repainting of interior and exterior walls.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$425,000
Rehabilitation and modification of building	LS	---	---	420,000
Utilities (outside 5' line)	LS	---	---	5,000
Equipment				$2,270,000
Provision of data gathering processor	LS	---	---	850,000
Provision of "real time" processor	LS	---	---	665,000
Data system installation and check out	LS	---	---	755,000
Fallout Shelter (Not Feasible)	---	---	---	---
	TOTAL			$2,695,000

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

There are presently no known future requirements to complete this work on the 11-Foot (3.4m) Transonic Wind Tunnel.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

PROJECT TITLE	Addition to Lunar Sample Curatorial Facility
LOCATION	Lyndon B. Johnson Space Center
	FY 1976 CoF ESTIMATE $2,490,000

COGNIZANT INSTALLATION: Lyndon B. Johnson Space Center

LOCATION OF PROJECT: Houston, Harris County, Texas

COGNIZANT PROGRAM OFFICE: Office of Space Science

FY 1975 AND PRIOR YEARS CoF FUNDING:

Planning and Design	$519,000
Construction	2,895,000
Total FY 1975 and Prior Years	$3,414,000

SUMMARY PURPOSE AND SCOPE:

This project provides for a 15,000 square foot (1,394 m^2) addition to the existing Lunar Curatorial Facility, Building 31, at JSC, to improve the effectiveness, safety and security of this facility used for the storage and handling of lunar samples.

PROJECT JUSTIFICATION:

The 840 pounds (381 kg) of lunar material brought to earth by the Apollo program are a tangible product of an enormous national effort, constituting an invaluable scientific resource that will be analyzed and studied for many years. The material has been cataloged into nearly 40,000 samples, which are being studied by approximately 150 principal investigators and 1,000 other scientists. The experience gained since 1969 in procedures for cataloging, handling and studying lunar samples has now culminated in an ability to better define requirements for further improved maintenance of sample cleanliness and more adequate measures to prevent degradation of these samples by the earth's atmosphere.

The Lunar Receiving Laboratory (LRL), Building 37 at JSC, was constructed in 1968 to handle the receipt of lunar samples. Its primary function was to provide a place for the quarantine of lunar rocks and astronauts. To a very

limited degree, it also provided for the processing of the samples for scientific examination. Because the LRL was not intended nor designed to handle the vast amount of lunar material, the Lunar Mission and Space Exploration Facility, Building 31, was modified in 1971 to provide more laboratory space and a more secure storage facility. This was in response to the increased amount of lunar material then envisioned and the very limited experience to that date with the inherent security and storage problems. There is presently some 10,162 square feet ($944m^2$) of space dedicated to lunar sample curatorial use at JSC. Of this amount, 4,623 square feet ($429m^2$) is for office space use, 4,963 square feet ($461m^2$) as laboratory and technical and support space, and 576 square feet ($54m^2$) are vaults for sample storage. The limited facility provided in Building 31, however, does not now meet all of the essential requirements for this total activity. More efficient and more closely integrated curatorial facilities are now needed. Among the other factors considered are safe secure storage as well as adequate laboratory space for visiting scientists.

As an interim and temporary measure, a large portion of the lunar material is presently in "temporary" vaults outside Building 31. These samples should be returned to the principal working collection as soon as possible for routine inspection by curatorial personnel and for ready accessibility by scientists. This is an example of the restrictive accommodations under which present operations must be carried out.

The quantity of lunar samples and the number of interested scientists are much greater than originally anticipated. Building 31, although reasonably adequate for sample processing, has no available laboratories which visiting scientists can use to examine pristine lunar samples. These samples cannot be removed because of the associated unacceptable risks. Building 31 does not provide properly sized, secure, clean storage vaults and the resultant problem of dispersed storage has been indicated above. The lunar facilities in Building 31 are not sufficiently elevated to afford adequate protection from any severe flood which might result from hurricanes or tropical storms. Additional protection is also deemed prudent to better deal with the potential problem of building and ground shock waves, sabotage or vandalism.

In light of the potential of these risks regardless of the protection, it is also planned that approximately 20% of the lunar sample collection will be relocated to a remote site. The modifications to reconfigure this site for this special storage are estimated to cost $250,000 and will be implemented through a prior years rehabilitation and modification project.

This separate FY 1976 CoF project provides the necessary addition to Building 31 for laboratories and storage vaults to increase efficiency in handling lunar material and to preclude the possibility of a major loss of samples from natural or manmade hazards. With this new capability we will have a total of approximately 24,260 square feet ($2,254m^2$) of space for lunar sample curatorial functions. This will include about 4,400 square feet ($409m^2$) of office area, 16,350 square feet ($1,519m^2$) of laboratory and technical area, and 2,400 square feet ($223m^2$) of vault storage space (not including the remote site). It is, therefore, seen that the major improvements involve laboratory/technical and vault storage space.

PROJECT DESCRIPTION:

The project will provide for the construction of a two-story addition to the existing Lunar Curatorial Facility, Building 31 at JSC. Each story will contain 7,500 square feet (697 m^2) for a total of 15,000 square feet (1,394 m^2).

The addition will include an ultraclean and highly secure vault, one section of which will be for storage of pristine lunar samples, and one section of which will be for samples that have been investigated. The vault will be located approximately 40 feet (12.2 m) above sea level for protection from floods. Small processing laboratories for visiting scientists, an equipment elevator, support rooms and laboratories, and data storage will be provided.

The necessary local and remote audible and visual alarms for secure lunar sample storage will be provided. Utilities for the annex will be extended from the existing utility tunnel for Building 31.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$2,490,000
Site preparation and utilities	LS	---	---	300,000
Structural and architectural (including vault)	LS	---	---	1,035,000
Mechanical systems	LS	---	---	790,000
Electrical system	LS	---	---	250,000
Sprinkler system	LS	---	---	20,000
Elevator	LS	---	---	95,000
Equipment	---	---	---	---
Fallout Shelter (Not Feasible)	---	---	---	---
	TOTAL			$2,490,000

An estimated $260,000 of new noncollateral equipment to include lunar sample storage and processing cabinets and other equipment is required to make the facility operational. This will be procurred from R&D resources. Existing gaseous nitrogen storage and processing cabinets and laboratory equipment, with an estimated value of $370,000, will also be used in the annex.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

It is presently estimated that no future program funding requirements are necessary to complete this project.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

PROJECT TITLE	Addition for Composite Model and Metal Finishing Shops
LOCATION	Langley Research Center
	FY 1976 CoF ESTIMATE $1,940,000

COGNIZANT INSTALLATION: Langley Research Center

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT PROGRAM OFFICE: Office of Aeronautics and Space Technology

FY 1975 AND PRIOR YEARS CoF FUNDING:

Planning and Design	$20,000
Construction	---
Total FY 1975 and Prior Years	$20,000

SUMMARY PURPOSE AND SCOPE:

This replacement project provides the essential shop space needed to properly support the functions of the Composite Model Development Shop and the Metal Finishing Shop. The existing shops were largely improvised over several years and are now functionally obsolete and improperly located. For years these very inadequate facilities have been used because no other facilities were available. The proposed facility will replace existing facilities built in 1940-41 which have deteriorated beyond economical rehabilitation and are not sufficiently adaptable to meet the present needs of the composite model and metal finishing work at Langley. With the growth of Langley Research Center over the years and the changes in the designs and materials used in the aeronautical programs, the progressively increasing responsibility and workload of the Model Development and Metal Finishing Branches has necessitated an increase in the amount and size of models and equipment to be produced or worked on. However, the space available in these structures has remained static throughout the Center's growth years.

This 36,000 square foot (3,344 sq. m) addition to an existing facility will permit consolidation of scattered and inadequate shop operations into

one shop complex at Langley, thereby improving fabrication efficiency and coordination, reducing safety hazards, and improving the cleanliness and quality of the projects produced or worked on in these shops. The proposed facility is a planned addition to the Laser and Optics Shop which is bordered on Durand Road where the new shop operations are now located. This proposed facility completes the final phase to relocate all shops at Langley into a single complex.

PROJECT JUSTIFICATION:

The proposed Composite Model Shop of about 30,000 square feet (2,787 sq. m) is required to replace the existing temporary 37,000 square foot (3,437 sq. m) structural complex built in 1940-41. This old building has now deteriorated to such a point that extensive upgrading is required to prolong usefulness of the facility for aerospace research. An adequate facility is needed for the fabrication of precise and complex research models. Present day model fabrication techniques involve the use of many types of resin and foam systems which require cleanliness in handling, exhausting of toxic fumes and stringent temperature-humidity-dust controls during fabrication. Close supervision must be provided to satisfy the model modifications required for the research test facilities since such model modifications are often made during the test programs. The proposed structure will provide a facility with the capability to produce test models of various sizes and complexity for aeronautics, structures, and a significant number of other activities at the Langley Research Center.

The Metal Finishing Shop with an area of about 6,000 square feet (557 sq. m), will provide for the chemical processes that encompass electrodeposition and surface chemistry technologies such as electroplate, electroform, anodize, chemical milling and cleaning, and chemical analyses which are currently being accomplished in two substandard buildings in a densely populated area. The existing facilities are severely limited in floor area, only 4,300 square feet (400 sq. m), which negates effective process segregation necessary to achieve optimum process control. The existing facilities lack adequate service utilities, optimum waste disposal, and environmental control.

This total Center facility shop improvement and equipment relocation is the final phase in Langley Research Center's long term plan to consolidate scattered and inadequate shop operations into a master planned shop complex located along Durand Road. The proposed addition will provide minimum accommodations for approximately 100 people who perform the various types of shop fabrication. These workers produce and maintain wind tunnel research models. They construct aerospace models, test components, inflatable and erectable structures of pliant materials. They also do fabrication research in advance fibers and resins and ceramic and heat transfer models. The integration of these various operations into a complex of shops will greatly improve the efficiency and coordination within these shops.

PROJECT DESCRIPTION:

This facility will be a one-story L-shaped structure with a high bay ceiling having a gross area of approximately 36,000 square feet (3,344 sq. m). The building will consist of two main areas, one the Composite Model Shop, 30,000 square feet (2,787 sq. m) and the other the Metal Finishing Shop, 6,000 square feet (557 sq. m). The total structure will house the fabrication operations of precise and complex research test models constructed of wood, ceramics, fiber glass and advanced composite materials as well as the chemical processing of metals. The facility will have a lumber conditioning room, storage area, fiber glass spraying and grinding area, clean fabrication area, clean room and dust collection area. Also included with this project are offices for about 12 personnel, rest rooms, air conditioning and all necessary utilities.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,915,000
Site development	LS	---	---	55,000
Architectural and structure	SF	36,000	24.72	890,000
Electrical (inside 5' line)	SF	36,000	8.20	295,000
Mechanical	SF	36,000	15.14	545,000
Utilities (outside 5' line)	LS	---	---	130,000
Equipment				25,000
Relocation of existing equipment	LS	---	---	25,000
Fallout Shelter (Not Feasible)	---	---	---	---
	TOTAL			$1,940,000

The Addition for the Composite Model and Metal Finishing Shops will involve approximately $1,100,000 of shop equipment of a noncollateral nature which will be relocated from the existing shops.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

At the present time there are no foreseeable requirements for future CoF funding for this project.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

SPACE SHUTTLE FACILITIES

	Amount	Page No.
Office of Manned Space Flight:		
Summary		CF 4-1
Launch and Landing Facilities	$35,410,000	
Modifications to Launch Complex 39, Kennedy Space Center, Florida	13,110,000	CF 4-5
Construction of Orbiter Processing Facility Kennedy Space Center, Florida	8,160,000	CF 4-12
Modifications for Solid Rocket Booster Processing Facilities, Kennedy Space Center, Florida	5,240,000	CF 4-18
Modifications for Hypergolic Checkout and Refurbishment Facilities, Kennedy Space Center, Florida	6,940,000	CF 4-25
Modifications for Launch Equipment Test Facilities, Kennedy Space Center, Florida	1,960,000	CF 4-31
Ground Test Facilities	8,810,000	
Construction of Orbiter Approach and Landing Test Facilities, Flight Research Center, Calif. and Palmdale, Calif.	1,680,000	CF 4-38
Construction of Shuttle/Carrier Aircraft Mating Facilities, Flight Research Center, Calif. and Palmdale, Calif.	3,890,000	CF 4-44
Modifications for Crew Training Facilities, Johnson Space Center	830,000	CF 4-49
Modification of the Vibration and Acoustic Test Facility, Johnson Space Center	2,410,000	CF 4-53
Manufacturing and Assembly Facilities	3,000,000	
Modifications for Solid Rocket Component Manufacturing and Assembly Facilities (Location to be designated)	3,000,000	CF 4-59
TOTAL	$47,220,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

PROJECT TITLE Space Shuttle Facilities	
	FY 1976 CoF Estimate $47,220,000

COGNIZANT INSTALLATION: Various Locations

LOCATION OF PROJECT: Locations are identified in the following documentation

COGNIZANT PROGRAM OFFICE: Office of Manned Space Flight

FY 1975 AND PRIOR YEARS CoF FUNDING:

Planning and Design	$22,325,000
Construction	180,310,000
Total FY 1975 and Prior Years	$202,635,000*

*For unique space shuttle facilities provided under the CoF program only.

SUMMARY PURPOSE AND SCOPE:

The purpose of these projects is to modify and add to existing Government-owned facilities and to construct those limited new facilities necessary to support the space shuttle program. As in prior years, this shuttle facility package includes all major facility requirements which are unique to the space shuttle program. All requirements are tied to a shuttle program milestone or "need date". Included in this package are all facility requirements needed to achieve that initial operational capability or capacity as set forth in the project documentation and/or the outline assumptions on which total shuttle facility needs have been based and projected.

In FY 1976 the shuttle facilities are again primarily for launch and landing requirements at John F. Kennedy Space Center (KSC). The work includes continuing the modifications to Launch Complex 39 and construction of the Orbiter Processing Facility, which were initiated with FY 1975 resources; modifying existing facilities to provide for launch equipment testing, and for checkout and maintenance of hypergolic fueled pods; and modifying existing Air Force facilities at the Cape for processing the solid rocket boosters (SRB's) before launch.

Fiscal Year 1976 requirements at other locations include continuation of construction and modifications for orbiter approach and landing test facilities, shuttle/carrier aircraft mating facilities, crew training facilities, vibro-acoustic facilities, and facility modifications for SRB component manufacturing and assembly operations.

PROJECT JUSTIFICATION:

Fiscal Year 1975 and prior years' Construction of Facilities projects for the space shuttle program authorized modifications and construction for technological facilities, engine test facilities for the shuttle, major manufacturing facilities, ground test facilities, and launch and landing facilities. Final design of all these facilities is underway and major portions of this design effort are complete. Construction work on a number of these early projects is now complete and several facilities are operational.

The FY 1976 request is intended primarily to continue modifications to provide launch capability for the shuttle at KSC. These facilities are needed for the initial operation at the launch and landing site. Included, is continuation of two projects begun with FY 1975 resources - modifications to Launch Complex 39 and construction of an Orbiter Processing Facility. Included also are the modifications to existing facilities to support solid rocket booster processing at the launch site, hypergolic pods checkout and maintenance, and launch equipment testing. With the exception of launch equipment testing, construction of the facilities must be completed 6-12 months before the first manned orbital flight. This schedule is required in order to support the necessary extensive activation, launch processing system installation, prelaunch test and checkout activities. The launch equipment test facility is needed by mid-CY 1977 to start testing swing and holddown arms that must be developed and verified in time for launch operations.

The remaining projects in the FY 1976 request are intended primarily to support vital ground and flight test activities and the manufacture and assembly of SRB components. They include continuing four FY 1975 projects intended to provide facilities for approach and landing tests, shuttle/carrier aircraft mating facilities, crew training and vibro-acoustic tests.

Current space shuttle planning is based on achieving an orbiter first captive flight in the second quarter of CY 1977 and a first manned orbital flight in the second quarter of CY 1979. This FY 1976 request is necessary to support these major milestones. Each project is required to meet a specific target or intermediate milestone directly related to the major milestones. The individual project descriptions specify those respective milestones to which the facility is related.

SUMMARY PROJECT COST ESTIMATE:

Launch and Landing Facilities	$35,410,000
Ground Test Facilities	8,810,000
Manufacturing and Assembly Facilities	3,000,000
TOTAL	$47,220,000

PROJECT COST ESTIMATE:

Launch and Landing Facilities	35,410,000
Modifications to Launch Complex 39, Kennedy Space Center, Florida	13,110,000
Construction of Orbiter Processing Facility, Kennedy Space Center, Florida	8,160,000
Modifications for Solid Rocket Booster Processing Facilities, Kennedy Space Center, Florida	5,240,000
Modifications for Hypergolic Checkout and Refurbishment Facilities, Kennedy Space Center, Florida	6,940,000
Modifications for Launch Equipment Test Facilities, Kennedy Space Center, Florida	1,960,000
Ground Test Facilities	8,810,000
Construction of Orbiter Approach and Landing Test Facilities, Flight Research Center, California, and Palmdale, California	1,680,000
Construction of Shuttle/Carrier Aircraft Mating Facilities, Various Locations	3,890,000
Modifications for Crew Training Facilities, Johnson Space Center, Houston, Texas	830,000
Modification of the Vibration and Acoustic Test Facility, Johnson Space Center, Houston, Texas	2,410,000
Manufacturing and Assembly Facilities	3,000,000
Modifications for Solid Rocket Booster Component Manufacturing and Assembly Facilities (location to be designated)	3,000,000

CF 4-3

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CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

PROJECT TITLE	Modifications to Launch Complex 39
LOCATION	John F. Kennedy Space Center
	FY 1976 CoF ESTIMATE $13,110,000

COGNIZANT INSTALLATION: John F. Kennedy Space Center

LOCATION OF PROJECT: Merritt Island, Brevard County, Florida

COGNIZANT PROGRAM OFFICE: Office of Manned Space Flight

FY 1975 AND PRIOR YEARS CoF FUNDING:

Planning and Design	$3,070,000
Construction	536,893,000
Total FY 1975 and Prior Years	$539,963,000

SUMMARY PURPOSE AND SCOPE:

This project is a continuation and extension of the modification work provided for in FY 1975 for Launch Complex 39. This FY 1976 project provides for modifying the Launch Control Center to provide facilities for accommodating instrumentation and control equipment required for checkout and launch. It also provides for the added resources necessary to complete the total work initially presented in the related FY 1975 project request.

PROJECT JUSTIFICATION:

The FY 1975 budget request was for modification to Pad A, one mobile launcher, and two high bays in the Vehicle Assembly Building (VAB). The FY 1975 resources ultimately provided were at a lower amount and this, coupled with escalating construction costs, made it necessary to defer certain work initially planned in FY 1975. This work consisted of launch systems, including propellant and high-pressure gas systems at the pad, the mobile launcher, and the VAB. This FY 1976 project provides for completing the pad, the mobile launcher, and the two high bays in the VAB.

To attain launch capability from Launch Complex 39, regardless of the number of flights, it is necessary to modify and adapt the Launch Control Center (LCC) to accommodate the shuttle launch processing system. This

system, to be developed and procured from R&D resources, provides the necessary electronic checkout, monitoring, and control functions during prelaunch operations as well as launch control of the shuttle system during countdown through lift-off. This project provides the necessary modification to the LCC to adapt it for shuttle launch operations.

To achieve the first manned orbital flight milestone as currently planned, the launch facilities must be operational no later than mid-CY 1978. This is necessary to allow for the extensive prelaunch activities, including receipt and checkout of the orbiter, external tank and solid rocket boosters; mating and integration; and flight-readiness firing of the orbiter engines, now scheduled several weeks before the first manned orbital flight. The launch facilities are large and complex, with critical interfaces with ground support equipment and the launch processing system, thus requiring extensive construction and activation periods. For these reasons, this project must be undertaken as scheduled in FY 1976.

PROJECT DESCRIPTION:

This project includes continuation of the work begun in the FY 1975 project and modifying the LCC.

Completion of Pad A, the Mobile Launcher and the VAB (two bays)

The FY 1975 increment of this project included extensive modifications of one launch pad, one mobile launcher, and two high bays of the VAB. This project provides for completing the modifications of these facilities. The work provides for extensive modifications of the launch systems, including the environmental control, propellant, and pneumatic systems on the mobile launcher; the environmental control, pneumatic, fuel, and high-pressure gas systems on Pad A, and the environmental control, pneumatic, and high-pressure gas systems in the VAB.

Modifications to the Launch Control Center

The second floor of the LCC and two firing rooms on the third floor will be modified to provide shuttle launch support. The second floor will contain the heart of the computer system. One firing room will directly support major integrated shuttle vehicle checkout and control, and individual shuttle vehicle ground support activities. A second firing room will be used for controlling nondirect vehicle systems, including control of the facility systems at Launch Complex 39, the Orbiter Processing Facility, and the Solid Rocket Booster Processing Facilities. An area will be provided for management control functions. The modifications include removing and/or modifying racks, partitions, walls, and doors; relocating and installing air conditioning equipment; modifying raised floors and chilled water systems; and providing a fire extinguishing system. Extensive electrical modifications will be required to adapt this facility for shuttle.

Standardized layouts for the control consoles, which will monitor separate functions of the shuttle launch and be tied into the central launch processing system on the second floor, will be used in the firing rooms. Cutouts in the flooring will be required to accommodate them. Existing racks and their associated underfloor cables, wireways, and receptacles will be removed; partitions, walls, doors, raised floors, and air conditioning and electrical systems will be modified. Additional air handling units will be installed to insure adequate cooling for the computer system.

Emergency power will also be provided. Instrumentation and power circuits will be expanded and reconnected to accommodate the new arrangement of the consoles. The existing air conditioning units for the launch processing system rooms and the central data system will be disconnected from their existing power source and reconnected to the emergency power to insure uninterrupted operation during a power failure. The chilled water system will also be modified to provide adequate cooling in the event of a power failure.

The area adjacent to the Firing Room 1 will be modified to provide an electronically-shielded communications security work room (COMSEC) and equipment room for Department of Defense missions. Existing doors will be removed and wall openings permanently closed; additional walls and new access doors will be provided. Double entry shielded doors and the electromagnetic shielding for the floor, walls, and ceiling of the COMSEC and equipment rooms are required. The electrical and air conditioning systems will be modified.

Although fire detection and alarm systems currently exist in the areas to be modified, a fire control and extinguishing system does not. Therefore, a fire extinguishing system, which will incorporate the present detection and alarm systems, will be installed in each area or room to be modified. In the event of a fire, the system will provide total freon flooding of areas above ceilings, under raised floors, and inside racks and consoles, thus permitting personnel to continue operations. This system is necessary to protect the high value equipment to be housed in the Launch Control Center.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$13,110,000
Modifications to launch control center	LS	---	---	2,810,000
Removal of racks, partitions, walls and doors	LS	---	---	(120,000)

	Unit of Measure	Quantity	Unit Cost	Total Cost
Modify raised floors	LS	---	---	(140,000)
Modify air conditioning system	LS	---	---	(170,000)
Modify electrical system	LS	---	---	(1,280,000)
Modification for COMSEC	LS	---	---	(270,000)
Fire protection and safety system	LS	---	---	(830,000)
Launch systems for Pad A, mobile launcher and VAB	LS	---	---	10,300,000
Equipment	---	---	---	---
Fallout Shelter (Not Feasible)	---	---	---	---
	TOTAL			$13,110,000

It is anticipated that approximately $38 million to $40 million worth of R&D resources will be required to provide the noncollateral communications, control and monitoring equipment required for initial operations.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

It is estimated that $55 million to $65 million will be required in future CoF programs to complete this project and provide additional launch facilities necessary to support the higher rate of flights anticipated. These CoF resources would be used to provide modifications for another pad, at least a second mobile launcher, two more high bays in the VAB, and possibly a third firing room in the LCC, and lightning protection for the space shuttle vehicle during transportation to the launch pad.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

PROJECT TITLE	Construction of Orbiter Processing Facility
LOCATION	John F. Kennedy Space Center
	FY 1976 CoF ESTIMATE $8,160,000

COGNIZANT INSTALLATION: John F. Kennedy Space Center

LOCATION OF PROJECT: Merritt Island, Brevard County, Florida

COGNIZANT PROGRAM OFFICE: Office of Manned Space Flight

FY 1975 AND PRIOR YEARS CoF FUNDING:

Planning and Design	$955,000
Construction	13,380,000
Total FY 1975 and Prior Years	$14,335,000

SUMMARY PURPOSE AND SCOPE:

This project is a continuation and extension of the construction work provided for in FY 1975 for the Orbiter Processing Facility at the Kennedy Space Center. The FY 1975 project included one large high bay area and a low bay required for "safing", maintenance and checkout of the space shuttle orbiter. This FY 1976 increment provides for the construction of the basic second high bay structure to complete the building construction as initially envisioned and now required. Outfitting the second high bay with the necessary air conditioning, gaseous and other special systems will be provided for in a future year program to support the developmental missions and, subsequently, the higher flight rates.

PROJECT JUSTIFICATION:

Upon returning from a space mission, the orbiter must undergo "safing", maintenance and checkout operations before it can be made ready for reuse. The major operations include drainage and purging of all fuel systems, removal of ordnance, removal of payloads brought back from space, inspection of the payload bay and crew cabin, repair and replacement of damaged components and

refurbishment of the thermal protection system. The hypergolic modules that make up the reaction control system, the orbital maneuvering system and components of the auxiliary power unit are removed in this facility; serviced and checked out in a separate facility; and then returned to the Orbiter Processing Facility for reinstallation into the orbiter. After these operations are completed, the mission payloads are inserted into the payload bay and the orbiter receives integrated system checkout before movement to the Vehicle Assembly Building for integration and checkout with the external tanks and the boosters. These are vital functions that take approximately two-thirds of the total orbiter processing time between missions. To effectively carry out these operations, the Orbiter Processing Facility is required.

The FY 1975 program provided the initial increment of the necessary facilities. That increment provided the first high bay area for orbiter operations and the low bay area for the support functions. This FY 1976 project will provide the basic structure for the second high bay area essential to complete all building construction. It is now planned to outfit the second high bay with the essential air conditioning, high pressure gas systems and special systems as a future year's program requirement. At that time, the facility will be capable of supporting the orbiter processing functions during the developmental phase of the shuttle as well as during the operational phase that follows.

Shuttle program plans require the use of the two high bays interchangeably to carry out all delineated orbiter processing operations. It has been recognized, however, that certain operations, particularly the "safing" operations, are very hazardous in nature. Others, such as thermal protection system refurbishment, are somewhat "dirty" by their nature and somewhat incompatible with the clean environment required for the removal and insertion of payloads into the orbiter payload bay. The facility is being designed to handle these complex tasks. However, a period of "learning" is absolutely vital to train personnel and to develop the detailed operational procedures required to do all these functions safely and efficiently using the same work stations. For these reasons, it is necessary to have both high bays available during the developmental phase of the shuttle program.

When completed, the first bay is planned to receive the orbiter and carry out the normal "safing", maintenance, and checkout operations as well as the payload inspection, insertion and removal functions. In the event these operations are found to be significantly incompatible, particularly for the initial developmental missions, the second bay will then provide the capability to separate these functions until a long term solution and/or vehicle maturity evolves. These plans will then allow sufficient time to train the operators and develop the procedures to permit each bay to carry out the total processing functions to support the higher mission profile projected in 1981 and beyond.

An analysis was made as to how best to construct the full planned scope of the orbiter processing facilities. As a result of this analysis, it has been determined that constructing the second high bay structure with FY 1976 resources is the optimum way in terms of facility engineering and at the same time accommodating the program requirements. Initiating construction of this second high bay in this time frame will preclude the potential interference between construction of this high bay and operation in the first; it will allow for consistency and standardization in facility construction that will result in optimizing the operation; and it clearly provides the most economical means of completing the total construction in time to meet the needs. To achieve these objectives, FY 1976 resources are necessary to implement the project as planned.

To meet the first manned orbital flight as currently scheduled, the first orbiter must be delivered to Kennedy Space Center in the third quarter of CY 1978 for the extended prelaunch activities and integration into the launch and landing complex. The first high bay, programmed in FY 1975, must be operationally ready by that time to meet this milestone. The second high bay, proposed in this project, must be completed and operable in the second quarter of 1979 to support the first manned orbital flight and the shuttle developmental flights that follow. To meet this schedule, construction of the basic structure must start in the third quarter of CY 1975, thus necessitating FY 1976 programming.

PROJECT DESCRIPTION:

This project is a continuation and extension of the construction work provided for in FY 1975 for the Orbiter Processing Facility at the Kennedy Space Center. The FY 1975 increment provided for the construction of a 29,100-square foot (2,703.4-m^2) high bay, a 25,000-square foot (2,322.5-m^2) low bay, and associated site work and utilities. The FY 1975 increment also provided the site work and limited foundations for the second high bay as well as for fully outfitting the first bay for its intended use. This FY 1976 project will provide for construction of the basic second high bay structure to complete the building construction. A future year program will provide for outfitting the second high bay with the special air conditioning, hydraulic and propellant systems, as well as the high-pressure gas and fuel systems required to support program requirements.

This second high bay will be identical to the first bay in size and in architectural motif. Like the first high bay, construction will consist of structural steel framing with insulated metal panel exterior walls. The building will be equipped with two 30-ton (27.2 metric tons) capacity bridge cranes with a hook height of approximately 70 feet (21.3 m) and floor area of approximately 29,100 square feet (2,703.4-m^2). An underground floor trench

system will be provided to accommodate utility and special gaseous and fuel systems that will be later installed. The basic utility systems, including water, electrical and lighting, and a deluge fire protection system will also be provided.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$7,370,000
Second high bay	CF	2,706,000	1.90	5,150,000
Site preparation, foundations	LS	---	---	590,000
Utility extensions	LS	---	---	1,350,000
Fire protection system	LS	---	---	280,000
Equipment	---	---	---	790,000
30-ton bridge crane	Each	2	395,000	790,000
Fallout Shelter (Not Feasible)	---	---	---	---
			TOTAL	$8,160,000

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

It is estimated that $5-6 million will be required in the future CoF programs to "outfit" this facility and make it an operational facility to support the shuttle developmental flights and the later scheduled higher flight rates. The outfitting will include the special air conditioning, high-pressure gas, hydraulic, propellant, instrumentation and control systems.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

PROJECT TITLE	Modifications for Solid Rocket Booster Processing Facilities
LOCATION	John F. Kennedy Space Center
	FY 1976 CoF ESTIMATE $5,240,000

COGNIZANT INSTALLATION: John F. Kennedy Space Center

LOCATION OF PROJECT: Merritt Island, Brevard County, Florida

COGNIZANT PROGRAM OFFICE: Office of Manned Space Flight

FY 1975 AND PRIOR YEARS CoF FUNDING:

Planning and Design	$720,000
Construction	---
Total FY 1975 and Prior Years	$720,000

SUMMARY PURPOSE AND SCOPE:

The purpose of this project is to provide modifications to existing Air Force Titan III solid rocket motor facilities at Cape Canaveral for receiving, storing, and assembling solid rocket booster (SRB) sections before movement to the Vehicle Assembly Building (VAB) for stacking, mating, and integrating with the external tank and orbiter.

The project includes modifying a portion of the high bay and low bay of the Solid Motor Assembly Building (SMAB) for receiving and off loading of solid rocket motor (SRM) segments, and for assembly of the forward and aft sections of the solid rocket booster (SRB); modifying portions of the Missile Inspection and Storage Building (MIS) for subassembly and storage of inert SRB components; and modifying the Segment Arrival Storage Area (SAS) to provide outside storage for the SRM segments. In addition to modifying these facilities to meet operational requirements, the existing road system from the Titan III area to the VAB will also be modified.

PROJECT JUSTIFICATION:

The shuttle vehicle consists of the orbiter, an external tank, and two solid rocket boosters. The two boosters provide the major portion of the thrust, approximately 2.5 million pounds, that is needed to place the orbiter in orbit. Each booster is composed of four solid rocket motor segments, forward and aft skirts, a nose cone, a nozzle, a thrust vector control mechanism, separation motors, parachute recovery system, and attachment structure. This hardware will be manufactured at various plants in the United States and delivered directly to the launch site where it will undergo essential processing operations before launch. These processing operations include receipt, inspection, and storage of the hardware, as well as detailed assembly of the various components into large sections before relocation to the VAB for stacking and intgration with the orbiter and external tank.

The solid rocket motor segments will arrive at Kennedy Space Center by rail and will be moved via an existing railroad system directly to the modified Titan III SMAB. Inside this facility the shipping covers will be removed and the segments will be inspected to assure that no damage has occurred during shipping. A large bridge crane will then be used to remove the motor segments from their railroad car transporter, rotate them from the horizontal to the vertical position, and place them into workstands or on pallets mounted on transporters for movement to the Segment Arrival Storage Area. The remaining SRB components upon arrival will be received and off-loaded in the SMAB or the existing MIS for inspection, storage, and later minor assembly. Capability to perform minor repairs to parts and components will also be provided.

After the SRM segments and SRB components are received, inspected and stored, critical major assembly operations on the forward and aft segments in the SMAB follow. The objective is to assemble these motor segments and components into two large sections for later movement to the VAB. The first is the forward subassembly section, which will include the nose cap, frustrum, parachute pack, forward thrust structure, forward skirt and forward SRM segment. When assembled, this section will be approximately 57 feet (17.4 m) long and will weight approximately 168 tons (152.4 metric tons). The second section is the aft subassembly section, which will weigh approximately 179 tons (162.4 metric tons) when completed. It will consist of the aft skirt, thrust vector control, separation rockets, nozzle extension, aft attachment ring, the aft SRM segment and the nozzle. Following the assembly operations, the large sections undergo alignment, pressure, electrical continuity, and other tests and are then hoisted from the assembly position onto transporters that move them to the VAB for the stacking and integration activities. To accomplish these important functions, modifications to the existing Titan III facilities are required.

The first manned orbital flight is currently scheduled for the second quarter of CY 1979. To achieve this goal, SRB components, including SRM's, should be delivered to KSC in the third quarter of CY 1978 for the start of the assembly operations. Consequently, the SRB processing facilities must be operationally ready at that time to meet program requirements. Modification and activation lead times, estimated at 32-34 months, require that construction must be started in the fourth quarter of CY 1975, thus necessitating FY 1976 programming.

PROJECT DESCRIPTION:

This project provides for modifying three existing Air Force Titan III facilities to receive, inspect, store and assemble major SRB segments before movement to the VAB for stacking and integration with the remaining shuttle vehicle.

The major work includes modifications to approximately 10,000 sq. ft. (929 m^2) of the 230 ft. (70.1 m) high bay area and approximately 14,000 sq. ft. (1,301 m^2) of the 140 ft. (42.7 m) high bay support area in the SMAB. This space, with the exception of 6,000 sq. ft. (557.4 m^2) of the 230 ft. (70.1 m) high bay area, will be used exclusively in support of the shuttle program. The remaining 6,000 sq. ft. (557.4 m^2) will be shared with Air Force on a noninterference basis to their programs. In addition, the existing MIS and SAS or two other comparable facilities will be modified to provide for receiving and storage of SRB components. Existing roads will be modified and extended to support movement of large SRB sections between the Titan III facilities and the VAB.

Modification work in SMAB primarily includes removal of the Titan III stands and provision for four new work stands specially configured to assemble the forward and aft sections of the SRB's. Each of the aft work stands will be equipped with four 5-ton (4.5 metric tons) hoists to perform subassembly operations. Associated extension of electrical and mechanical utilities is also included. The existing 300-ton (272.2 metric tons) bridge crane will undergo major modifications to adapt it for the SRB assembly functions. The modifications will include provisions for a new drum and cabling to increase vertical travel capability from 20 ft. to 80 ft. (6.1 m to 24.4 m). In addition, a second 300-ton (272.2 metric tons) hoist, and hoist trolley will be provided.

The 140 ft. (42.7 m) high bay support area will be used for processing and subassembly of smaller components including nozzle, nose cones and parachutes and for providing a work area, tool crib, storage, and necessary administrative and engineering space. To support these functions, four subassembly workstands will be constructed. The work also includes strengthening the floors to support the increased loading, and modifications and extension of utilities throughout the area. A new compressed

air system and extension of fire protection system will be provided. Also included are modifications to the ceilings, lighting and air conditioning to provide the necessary engineering and administrative space.

To provide the necessary access between the Titan III facilities and the VAB, the existing road system will be modified. The work includes upgrading and repairing approximately 8 miles (12.9 km) of the existing roadways, and constructing a new 24 foot wide (7.3 meters) by 3,000 foot (914.4 meters) long road to bypass Pad 41, and provision of passing turnouts as required.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$3,300,000
Modify SMAB	LS	---	---	2,500,000
Remove Titan stands	LS	---	---	(530,000)
Four new workstands in 230 foot high bay	LS	---	---	(900,000)
Four workstands in 140 foot high bay	LS	---	---	(220,000)
Modify mechanical systems	LS	---	---	(280,000)
Modify electrical systems	LS	---	---	(400,000)
Fire protection system	LS	---	---	(170,000)
Modify MIS	LS	---	---	80,000
Modify SAS	LS	---	---	250,000
Road modifications and extensions	LS	---	---	470,000
Equipment				1,940,000
Modify 300-ton bridge crane	LS	---	---	1,860,000
5-ton hoist	Each	8	10,000	80,000
Fallout Shelter (Not Feasible)	---	---	---	---
	TOTAL			$5,240,000

It is anticipated that approximately $8 to $9 million of R&D resources will be required to provide noncollateral equipment (e.g., assembly tooling equipment, special test sets, special handling equipment, and other ground support equipment) for this facility needed for initial operations.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

Additional work area may be required for processing SRB's to support the later scheduled higher flight rates. The need and scope of work required cannot be determined at this time. However, it is estimated that $8 to $10 million will be required in future CoF programs to provide a recovery facility for receipt, disassembly, washdown, and inspection of SRB's recovered after reentry.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

PROJECT TITLE	Modifications for Hypergolic Checkout and Refurbishment Facilities
LOCATION	John F. Kennnedy Space Center
	FY 1976 CoF ESTIMATES $6,940,000

COGNIZANT INSTALLATION: John F. Kennedy Space Center

LOCATION OF PROJECT: Merritt Island, Brevard County, Florida

COGNIZANT PROGRAM OFFICE: Office of Manned Space Flight

FY 1975 AND PRIOR YEARS CoF FUNDING:

Planning and Design	$545,000
Construction	6,233,000
Total FY 1975 and Prior Years	$6,778,000

SUMMARY PURPOSE AND SCOPE:

The purpose of this project is to provide modifications to existing facilities necessary to accomplish vital functions required for decontamination, maintenance, testing, and storage of hypergolic propellant modules after they have been removed from the orbiter during the "safing" operations in the Orbiter Processing Facility (OPF). After the above outlined processes are completed, the hypergolic modules will be returned to the OPF for reinstallation in the orbiter. The project provides for structural, mechanical, and electrical modifications to five existing buildings in the "fluid test complex" at KSC to provide maintenance and test cells, remote control stations, and support and storage facilities.

PROJECT JUSTIFICATION:

The orbiter will undergo extensive testing before its first manned orbital flight. After returning from a space mission, the vehicle will also undergo comprehensive "safing," refurbishment and checkout operations to ready it for reuse. The majority of these critical operations will be performed in the OPF. However, three of the orbiter systems use hypergolic propellants which are extremely hazardous. These systems include the orbital maneuvering system

(OMS), the reaction control system (RCS), and the auxiliary power unit (APU). In addition, the payload bay kit contains additional hypergolic propellant for the OMS/RCS systems to provide extra velocity change capability. Because of the extremely hazardous nature of the propellants involved, the systems must be tested and refurbished in special and remote facilities. This project provides the capability to meet these objectives.

The hypergolic pods are designed to be removed from the orbiter after each flight. Subsequently, the pods will be transported on dollies to remote facilities, where the modules will be placed in isolated cells. The cells must be designed, equipped, and controlled to handle the very hazardous propellants and the sensitive test and refurbishment operations that must follow. The operations include functional integrity checks for each module and for the system as a whole. The functional tests provide electrical continuity checks, and valve response checks in terms of opening and closing at precisely the right times. Leak checks will be performed for all propellant tanks involved. This is necessary because hypergolic propellant leakage is serious, not only in terms of the hazards and fuel losses, but also in terms of corrosion to adjacent vehicle components that could cause malfunction and failure. Other important operations include decontamination of the modules, engine pressure and functional checks excluding firings, and verification and calibration of the OMS/RCS instrumentation and control systems. To accomplish these significant activities, the proposed facility modifications are required.

The hazardous propellants used in the hypergolic modules necessitate a remote location for checkout, maintenance, and refurbishment operations. Modifying five of the existing buildings in the "fluid test complex" is more economical than building a new hypergolic complex. These five buildings were originally constructed for a similar purpose but need modifications to upgrade them for the more sophisticated requirements and new hardware of the shuttle program.

The first manned orbital flight is currently scheduled for the second quarter of CY 1979. To achieve this goal, the first orbiter should be delivered to KSC in the third quarter of CY 1978 for extended and essential prelaunch activities. Consequently, the hypergolic complex must be operational at that time to meet critical program requirements. Modification and activation lead times, estimated at 30 to 34 months, require that the project be started in early CY 1976, thus necessitating FY 1976 programming.

PROJECT DESCRIPTION:

This project provides for modifying five existing buildings in the"fluid test complex" to checkout, maintain, refurbish and store hypergolic pods. It includes modifying buildings and adjacent exterior areas, removing nonessential systems, installing new mechanical and electrical systems, and constructing fluid drains and holding facilities.

Building M7-961 will be used to process the OMS and aft RCS modules; Building M7-1212 will be used to process the payload bay kit and the forward RCS module. Work includes refurbishing all interior and exterior surfaces, overhead cranes, and door seals; modifying and extending utility systems as required; and removing existing piping and equipment. A new hypergolic piping system and associated spill drains will be installed. A compressed air system, and high pressure gaseous nitrogen and helium systems will also be procured and installed to carry out the pressure tests, leak test and the purging and cleaning of the OMS and RCS modules.

Building M7-1061 will be modified to accommodate and house launch processing system control consoles, self-contained atmospheric protective ensemble support, and to provide space for administration and logistics functions. The necessary work includes refurbishing all interior and exterior surfaces, including a clean room; rehabilitating and extending utility systems; removing existing piping and equipment; and replacing the roof. A new fire protection system, major electrical modifications, installation of pneumatic system and erection of partitions will be required. The project scope also includes the relocation of existing prototype shops to another facility.

Building M7-1410 and M7-1412 will be modified to provide environmentally controlled storage area for the payload bay kit, forward RCS,OMS, and aft RCS modules. Modification work includes rehabilitating the utility systems, high bay roof, vertical sliding doors, and interior and exterior surfaces. Replacing the low bay roof; procuring and installing a pneumatic system; modifying plumbing, ventilating, and air conditioning systems and upgrading the lighting to accommodate functional requirements will also be required.

Exterior work will include providing pads for hypergolic equipment,propellant disposal ponds, spill drains and associated gravity feed piping system. In addition, a 222-square yard (186m^2) asphaltic concrete apron will also be provided.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$6,940,000
Site work	LS	---	---	827,000
Building M7-961	LS	---	---	2,623,000
Building M7-1212	LS	---	---	1,872,000
Building M7-1061	LS	---	---	981,000

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	Unit of Measure	Quantity	Unit Cost	Total Cost
Building M7-1410	LS	---	---	328,000
Building M7-1412	LS	---	---	309,000
Equipment	---	---	---	---
Fallout Shelter (Not Feasible)	---	---	---	---
		TOTAL		$6,940,000

For initial operations, it is anticipated that approximately $12-$13 million of R&D resources will be required to provide associated noncollateral equipment.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

For presently planned usage, there are no currently foreseen future funding requirements necessary to complete this project.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

PROJECT TITLE	Modifications for Launch Equipment Test Facilities
LOCATION	John F. Kennedy Space Center
	FY 1976 CoF ESTIMATE $1,960,000

COGNIZANT INSTALLATION: John F. Kennedy Space Center

LOCATION OF PROJECT: Merritt Island, Brevard County, Florida

COGNIZANT PROGRAM OFFICE: Office of Manned Space Flight

FY 1975 AND PRIOR YEARS CoF FUNDING:

Planning and Design	$115,000
Construction	2,366,000
Total FY 1975 and Prior Years	$2,481,000

SUMMARY PURPOSE AND SCOPE:

The purpose of this project is to provide a facility to develop, test and certify, through structural and operational simulation, reusable launch critical ground support equipment. This equipment includes umbilical-type launch accessories, holddown arms, and swing arms that will be integrated into the launch facilities to provide operable capability to launch the space shuttle vehicle. The project includes modifications to portions of the Supply, Shipping, and Receiving Facility, Building M7-505, and the adjacent parking lot to accommodate simulators, test equipment, and supporting utilities.

PROJECT JUSTIFICATION:

Repeated launchings of the space shuttle vehicle require ground support equipment to be developed and evaluated by standards far exceeding those of previous space programs. This equipment includes the orbiter access swing arm, which provides the flight crew and mission specialists access to the orbiter's crew module; the orbiter tail umbilical masts; the external tank gaseous hydrogen vent umbilical; the orbiter's environmental control and life support system umbilical; and the solid rocket booster holddown

arms. This critical ground support equipment must be developed, tested, and certified before installation in the launch complex to insure launch integrity and reliability as well as reusability and maintainability throughout the span of the shuttle program. The equipment must operate flawlessly and precisely to insure a successful launch. To provide for developing, testing and certifying this equipment for its critical tasks, this facility capability is necessary.

These launch accessories are subjected to stringent forces and loads before and during the launch. To insure the ability of the equipment to withstand the static and dynamic forces involved, each swing arm and umbilical will be separately subjected to similar loadings in a test facility. At a predetermined exact point in the countdown or at the precise moment of launch, the various accessories must swing, retract and/or fall away from the shuttle vehicle for a successful lift-off. Consequently, these motions must be simulated for the individual items to certify that the equipment is capable of performing its exacting task. To carry out the structural testing and simulation tests involved, this proposed facility capability is necessary. Without this test facility, the vital development and certification testing cannot be performed prior to an actual launch lift-off.

NASA studies show that the most effective way to satisfy these requirements is to modify existing Building M7-505 at KSC and an adjacent paved area. This site offers earliest availability for low-cost construction modifications and is adequately sized to accommodate ground support and related test equipment. It will provide a central facility for engineering, test, and administrative personnel. Proximity to the shuttle launch complex simplifies continuing evaluation of reusable components.

To meet the approved schedule for the first manned orbital flight, work on this project must begin by the end of CY 1975 and be completed during the second quarter of CY 1977. Development, evaluation and acceptance testing of ground support equipment must be completed by early CY 1978 to allow integration into the launch complex for extensive, essential prelaunch activities there. Modifications as presently scheduled will allow sufficient time for testing ground support equipment, and FY 1976 funds are required to comply with the schedule.

PROJECT DESCRIPTION:

This project includes modification to the Supply, Shipping and Receiving Facility, Building M7-505, and the adjacent exterior area to provide capability for testing and certifying critical launch ground support equipment. An existing room, within Building M7-505, will be modified for a data acquisition and control center for acquiring test data and controlling the total test operations. The work includes extension of special electric service, air conditioning modifications, procurement and

installation of cabling and upgrading the existing lighting. The instrumentation and control equipment will be made available from existing inventory.

The exterior area modifications include construction of a pile foundation and erection of a 58-foot high (17.7 m) test tower from existing steel members at the Kennedy Space Center. Four existing hydraulic pumps will be relocated and installed at the base of the tower. These pumps will provide the necessary hydraulic power to operate the motion simulators. The work also includes construction of heavy foundations for the SRB holddown arms, random motion and lift-off simulators and a pad for the tail service masts. A suitable foundation and structure for attaching the orbiter emergency egress arm when it is in the retracted position during development and testing are included. Concrete trenches for instrumentation lines, gaseous nitrogen and hydraulic piping, and power cabling, as well as sufficient electrical modifications to provide power to all test articles, must be provided.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,960,000
Site preparation and utilities	LS	---	---	105,000
Building M7-505 modifications (Data acquisition and control)	LS	---	---	55,000
Erection of 58-foot tower and foundations	LS	---	---	469,000
Electrical, mechanical, and instrumentation systems	LS	---	---	1,088,000
Equipment pads and structures	LS	---	---	243,000
Equipment	---	---	---	---
Fallout Shelter (Not Feasible)	---	---	---	---
	TOTAL			$1,960,000

For initial operations, it is anticipated that approximately $550,000 of R&D resources will be required for refurbishment, modification and installation of existing simulators and other noncollateral equipment, and purchase and installation of such new equipment. Much of the hardware and test equipment can be adapted from existing Apollo program equipment available at NASA. Existing noncollateral equipment valued at approximately $1.9 million will be used in this launch facility.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

For presently planned usage, there are no currently foreseen future funding requirements necessary to complete this project.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

PROJECT TITLE	Construction of Orbiter Approach and Landing Test Facilities
LOCATION	Flight Research Center and Air Force Plant #42, Palmdale
	FY 1976 CoF ESTIMATE $1,680,000

COGNIZANT INSTALLATIONS: John F. Kennedy Space Center and Lyndon B. Johnson Space Center

LOCATION OF PROJECT: Edwards, Kern County, California
Palmdale, Los Angeles County, California

COGNIZANT PROGRAM OFFICE: Office of Manned Space Flight

FY 1975 AND PRIOR YEARS CoF FUNDING:

Planning and Design	$364,000
Construction	2,940,000
Total FY 1975 and Prior Years	$3,304,000

SUMMARY PURPOSE AND SCOPE:

This project is a continuation and extension of the construction work provided for in FY 1975 for the Orbiter Horizontal Flight Test Facilities. The FY 1975 project provided for an orbiter flight test hangar, shop and office space, and associated site work at Flight Research Center in connection with the use of Edwards Air Force Base for the orbiter approach and landing test (ALT) program. The FY 1976 project will provide shelters for the microwave scanning beam landing system (MSBLS) and hazardous material storage facilities at Flight Research Center (FRC); a new building to house the acceptance checkout equipment (ACE) at Palmdale; and a microwave transmission system between FRC and Palmdale to transmit data for the orbiter approach and landing test program.

PROJECT JUSTIFICATION:

The space shuttle orbiter as originally envisioned was to be equipped with removable air-breathing engines to provide the capability for aerodynamic flight. The decision in early CY 1974 to delete the air-breathing engines

also resulted in a revised concept for testing the orbiter in the airborne mode. The present flight test program calls for the orbiter to fly "piggyback" on top of a Boeing 747 aircraft and be dropped from an altitude of approximately 30,000-feet (9,144 m). The orbiter will then approach the runway and land in an unpowered mode. The test objectives include verifying the vehicle's stability and control, basic aerodynamics, and automatic landing system; and developing checkout and flight procedures. To provide the automatic landing capability for the orbiter, a microwave scanning beam landing system (MSBLS) will be required at Edwards Air Force Base. This is an extremely critical system since there is no "go-around" capability for the orbiter as there is with a conventional aircraft. This FY 1976 project will provide the necessary structures, utilities, and site work necessary to accommodate the MSBLS.

With the deletion of the air-breathing engines, the orbiter must now provide its own electric and hydraulic power to operate the crew cabin systems and the vehicle's control surfaces. The power requirement will be satisfied by installing the hydrazine-fueled auxiliary power unit (APU), hydrogen/oxygen fuel cells, and an ammonia coolant system. These are hazardous materials requiring special handling and imposing the need for extra safety measures. FY 1975 resources provided for a maintenance hangar that will be equipped to process an orbiter containing these hazardous fuels. This FY 1976 project provides the necessary exterior facilities required to safely store and handle the hazardous fluids and associated ground support equipment.

The orbiter will undergo extensive checkout activities to prepare it for its first approach and landing test flight. These activities include checking each subsystem - e.g., guidance and navigation, communication, power, hydraulic, environmental control - to insure that they are flight-worthy. A computerized checkout and control capability is required to monitor, evaluate, and control these preflight operations. Similar checkout operations will also be implemented after the orbiter lands and during the safing and post-flight testing that follow. It has been determined that these requirements can best be met by modifying and using ACE previously used for Apollo. This FY 1976 project provides for a new building, at the southeast corner of Building 294 at Palmdale, to house and accommodate this modified ACE. Palmdale was selected as the best location because the experienced and expert manpower required to operate the ACE will be available there to checkout the orbiter during final assembly. In addition, the ACE to be used in the final assembly operations could be readily switched to support the approach and landing test should a failure occur in any of this ALT-dedicated ACE equipment. The ACE equipment will be connected to Flight Research Center via a microwave transmission system.

To achieve the first approach and landing test as presently approved, these facilities must be operable in early CY 1977 to allow sufficient time for checkout of the orbiter prior to the first flight test. Therefore, construction must begin in late CY 1975, making FY 1976 programming necessary.

PROJECT DESCRIPTION:

This project provides for constructing four buildings to house the MSBLS at Edwards Air Force Base, exterior facilities to store hazardous materials at FRC, a new building to house acceptance checkout equipment at Palmdale, and a microwave transmission system connecting FRC to Palmdale.

The MSBLS, which provides guidance and control for automatic landing of the orbiter, will be housed in four air conditioned buildings. Two of the buildings will be constructed on each end of the main runway at Edwards AFB; one of the two on each end will be for the azimuth system, the other for the elevation system. Each building will be approximately 20 feet long by 16 feet wide by 10 feet high (6.1-m x 4.9-m x 3.0-m), with one side of the building constructed of material compatible with microwave frequencies. An uninterruptible power supply system essential for the operation of equipment and associated utilities will be provided at each site.

The hazardous storage facilities will be located in a remote area approximately 1,500 feet (457.2-m) to the west of the proposed hangar location. The site will consist of two 120-foot by 200-foot (36.6-m x 67.1-m) concrete slabs for handling and storing the hazardous fuels and the ground support equipment. Catch basins, sump pumps, fire protection systems, explosion-proof electrical systems for lights and power receptacles, and security fencing will also be provided.

The new building to house the acceptance checkout equipment at Palmdale will be located immediately adjacent to existing Building 294, at Air Force Plant #42. The site was selected to shorten utility and communication lines between this facility and Building 294. The building will be a masonry structure of approximately 4,000 square feet (371.6 m^2), with raised flooring, a suspended ceiling, and a fire detection and protection system. A 100-ton air conditioning system, with associated cooling tower and two 50-ton chillers, to handle the high heat loads from the computer equipment will be installed. A 1,000-KVA power substation will also be installed. A platform from Building 294 to the roof of the new ACE building will be constructed to provide access to the air conditioning equipment. A microwave transmission system will also be provided to transmit data between this ACE building at Palmdale and FRC.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,680,000
MSBLS (FRC)				300,000
Generators and shelters	Each	8	12,000	(96,000)
MSBLS structures	Each	4	51,000	(204,000)
Hazardous storage facilities (FRC)	Each	2	160,000	320,000
ACE Building (Palmdale)	---	---	---	820,000
Site preparation and foundations	LS	---	---	(20,000)
Architectural and structural	SF	4,000	50.00	(200,000)
Special air conditioning systems	LS	---	---	(265,000)
Fire protection system	LS	---	---	(80,000)
1,000-KVA substation and special electrical systems	LS	---	---	(255,000)
Microwave transmission systems	LS	---	---	240,000
Equipment	---	---	---	---
Fallout Shelter (Not Feasible)	---	---	---	---
	TOTAL			$1,680,000

For initial operations, it is anticipated that approximately $2 million of R&D resources will be required to provide the MSBLS and communication equipment. Existing acceptance checkout equipment valued at $6-7 million will be installed in the ACE Building at Palmdale.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

For the approach and landing test program, there are no currently foreseen future CoF funding requirements necessary to complete this project. However, additional modifications may be made to the approach and landing test hangar in a future year to meet payload removal requirements, should this site be used as a secondary landing site.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

PROJECT TITLE	Construction of Shuttle/Carrier Aircraft Mating Facilities
LOCATION	Various Locations
	FY 1976 CoF ESTIMATE $3,890,000

COGNIZANT INSTALLATION: John F. Kennedy Space Center and Lyndon B. Johnson Space Center

LOCATION OF PROJECT: Palmdale, Los Angeles County, California; Edwards, Kern County, California

COGNIZANT PROGRAM OFFICE: Office of Manned Space Flight

FY 1975 AND PRIOR YEARS CoF FUNDING:

Planning and Design	$483,000
Construction	4,200,000
Total FY 1975 and Prior Years	$4,683,000

SUMMARY PURPOSE AND SCOPE:

This project is a continuation and extension of the construction work for shuttle/carrier aircraft mating facilities at Flight Research Center (FRC) and Palmdale, California, which was provided for with prior years' resources. The earlier project provided for utilities, a towway, and orbiter safing facilities at FRC as well as for the long-lead procurement of steel, hoists, and other necessary materials for the mating facilities at FRC and Palmdale. This FY 1976 project provides for completing shuttle/carrier aircraft mating facilities at FRC and Palmdale.

PROJECT JUSTIFICATION:

The space shuttle orbiter as originally envisioned was to be equipped with removable air-breathing engines. The decision in early CY 1974 to delete the engines resulted in different approaches to transporting and aerodynamic testing of the orbiter. It has now been decided to transport and flight test the orbiter in a "piggyback" arrangement on top of a Boeing 747 aircraft, thus requiring orbiter mating/demating facilities at FRC and Palmdale.

Prior to vertical launch of the space shuttle, the orbiter must undergo atmospheric flight testing to verify its performance during subsonic approach and landing tests. The test program will include verification of orbiter airborne flight systems as well as those of the 747 aircraft performance while carrying the orbiter. To perform this testing, the orbiter will be carried aloft on the back of the 747 aircraft and air dropped from approximately 30,000 feet (9,144-m) in order to verify stability and control, basic aerodynamics, and automatic landing capability; and to develop mating/demating, maintenance, and checkout procedures for the orbiter. Mating/demating facilities must be available at Palmdale to mate the first flight orbiter to the 747 aircraft and must be available at FRC to mate and demate the orbiter during the approach and landing flight test program.

To meet the first approach and landing flight milestone now scheduled for the third quarter of CY 1977, a first captive flight test at FRC must be achieved in the second quarter of CY 1977. This requires that the mating facilities at FRC and Palmdale must be operable in early calendar year 1977 to achieve program objectives. Consequently, prior years resources will be used to initiate the long-lead facility items and FY 1976 resources will be required to complete the facilities.

PROJECT DESCRIPTION:

This project includes continuation and extension of work to be started with prior years' funds to provide operable shuttle/carrier aircraft mating facilities at FRC and Palmdale. The FRC program includes fabricating and erecting the steel structure and installing the hoist mechanism, movable platforms, elevator, and various piping systems to support the safing, deservicing, mating and demating operations. Palmdale work will include site preparation, and supplying utilities and foundation work to anchor the structure to an existing concrete base. Erecting the steel and installing hoist mechanisms and movable platforms must also be accomplished at Palmdale.

The mating/demating facilities will be structural steel, gantry-type, cantilevered structures approximately 100 feet (30.5-m) high, with a hoisting device capable of lifting approximately 225,000 pounds (102,058 kg). The mating facilities will be designed in such a way as to allow disassembly and relocation by air of these structures for use at the launch and landing, final assembly, test sites, or contingency landing sites as necessary to meet shuttle program requirements. Provisions will also be made for accommodation of external tank mating capability to the 747 aircraft to permit transportation of the tanks from the assembly to the launch sites. The additional facilities to achieve such an external tank transportation capability, should that be later required, could then be added in a future CoF program.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$3,890,000
FRC mating facility	LS	---	---	2,060,000
Site preparation, utilities, and foundations at Palmdale	LS	---	---	200,000
Palmdale mating facility	LS	---	---	1,630,000
Equipment	---	---	---	---
Fallout Shelter (Not Feasible)	---	---	---	---
	TOTAL			$3,890,000

For initial operations, it is estimated that approximately $1.5 million of R&D resources will be required for ground and test support equipment to support the safing, mating and demating operations of the orbiter and the carrier aircraft.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

For presently planned usage, there are no currently foreseen future funding requirements necessary to complete this work at FRC and Palmdale. Shuttle/carrier aircraft mating facilities will, however, be required at the launch site. These facilities, estimated at $2.5-$3.0 million, will be requested in a future CoF program. In addition, facility modifications estimated at $200,000 per mating facility will be needed if external tank air transportation capability is later required.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

PROJECT TITLE	Modifications for Crew Training Facilities
LOCATION	Lyndon B. Johnson Space Center, Texas
	FY 1976 CoF ESTIMATE $830,000

COGNIZANT INSTALLATION: Lyndon B. Johnson Space Center

LOCATION OF PROJECT: Houston, Harris County, Texas

COGNIZANT PROGRAM OFFICE: Office of Manned Space Flight

FY 1975 AND PRIOR YEARS CoF FUNDING:

Planning and Design	$99,000
Construction	3,030,000
Total FY 1975 and Prior Years	$3,129,000

SUMMARY PURPOSE AND SCOPE:

This project is a continuation and extension of the FY 1975 increment, which provided for modifications of existing facilities at the Johnson Space Center to support ground and flight crew training requirements. This FY 1976 increment provides for modification to the Mission Simulation and Training Facility, Building 5, to accommodate the shuttle mission simulator (SMS) and associated visual scene generation system. This work is essential to support ground and flight crew training for shuttle operations.

PROJECT JUSTIFICATION:

Crew training in ground facilities, using unique simulation equipment, has been a key factor in the success of manned space flight programs to date. Existing training facilities at the Johnson Space Center have been specifically constructed and successfully used to support the training activities for Gemini, Apollo and Skylab. To meet the training requirement for shuttle operations, modifications to this facility will be required.

FY 1975 CoF resources provided for the modifications to the Mission Simulation and Training Facility required to accommodate the orbiter aero-flight simulator (OAS), previously designated the horizontal flight test

simulator, and shuttle mission simulator (SMS) computer. The OAS is initially required to provide the crew training necessary to support the orbiter approach and landing testing in the atmosphere. The SMS computer is necessary to initiate software development for simulated flight missions. This FY 1976 project provides those modifications to the same facility now required to accommodate the SMS, which is the principal flight crew ground trainer for the space shuttle program.

The SMS will operate in conjunction with the Mission Control Center to provide training for ground controllers and flight crews in the operation of all orbiter systems in the various mission phases. It will simulate the shuttle flight in the launch, ascent and abort modes as well as during all orbital and recovery maneuvers. Accurate and animated visual scenes for the various mission phases will also be simulated. In addition, the crew and payload specialists will train in operating the payload manipulator used for capturing or releasing payloads during the mission. This project provides for facility modifications necessary to support these training activities.

Current program milestones require that components of the SMS be delivered in the first quarter of CY 1977 for installation into Building 5. Therefore, the facility modifications must be complete by that time to meet these needs. This requires FY 1976 programming.

PROJECT DESCRIPTION:

This project provides modifications to the Mission Simulation and Training Facility, Building 5, to house the shuttle mission simulator and its associated high and low altitude image generation systems.

In Building 5, modifications to approximately 15,200 square feet (1,412m^2) of space will be required. This work includes strengthening the floors for equipment foundations, extensive modifications of electrical power distribution system, procurement and installation of a 3,000-KVA substation with three transformers and associated switchgear, provision of approximately 4,000 square feet (372m^2) of computer flooring, modification to the air conditioning system, procurement and installation of sprinkler system, provision for special lighting for the visual generation equipment, removal of equipment and structures, and changes to interior walls.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$830,000
Simulator area modifications	LS	---	---	180,000
Fire detection and suppression systems	LS	---	---	100,000
Electrical and mechanical mods	LS	---	---	550,000
Equipment	---	---	---	---
Fallout Shelter (Not Feasible)	---	---	---	---
			TOTAL	$830,000

The shuttle mission simulator and associated visual scene generation systems will be developed and procured from the R&D appropriation. Existing simulation equipment, valued at about $5.0 million, will also be used in conjunction with these crew training facilities.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

It is estimated that approximately $300,000-$400,000 will be required in future year programs to accommodate shuttle simulators and associated equipment in support of crew training activities.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

PROJECT TITLE	Modification of the Vibration and Acoustic Test Facility
LOCATION	Lyndon B. Johnson Space Center
	FY 1976 CoF ESTIMATE $2,410,000

COGNIZANT INSTALLATION: Lyndon B. Johnson Space Center

LOCATION OF PROJECT: Houston, Harris County, Texas

COGNIZANT PROGRAM OFFICE: Office of Manned Space Flight

FY 1975 AND PRIOR YEARS CoF FUNDING:

Planning and Design	$437,000
Construction	6,792,000
Total FY 1975 and Prior Years	$7,229,000

SUMMARY PURPOSE AND SCOPE:

This project provides for increased acoustic generation capability within the existing reverberant chamber of the Vibration and Acoustic Test Facility (VATF), Building 49, at Johnson Space Center. This capability is necessary to support the vibro-acoustic test requirement for the orbiter aft fuselage.

PROJECT JUSTIFICATION:

The FY 1973 and FY 1975 Construction of Facilities program provided for modifying the VATF in support of the shuttle program. The work included a sonic fatigue test cell addition to carry out acoustic fatigue testing on full-scale sections of the orbiter with the thermal protection system (TPS) and rehabilitation of existing amplifiers. In addition, the FY 1973 project provided for modifying the existing acoustic reverberant chamber to permit test hardware to be subjected to a noise level of 160 decibels (dB), the approximate sound pressure level then estimated as being necessary to meet program requirements. Based on the latest best estimates of support contractors and NASA, this 160 dB level will satisfy the test requirements for all segments of the orbiter except the aft fuselage. It is now estimated that this aft section will encounter noise levels of 164 to 165 dB at lift-off. This project will provide the necessary additional noise generation capability to simulate the maximum level of flight acoustic environment now anticipated for the aft fuselage.

CF 4-53

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The orbiter will be subjected to severe noise impingement during lift-off and ascent which will significantly affect the structural design of the overall vehicle. To provide for the presently estimated 164 dB sound pressure level that the aft section will encounter at lift-off, the existing reverberant chamber must be modified so as to be able to generate a noise level of approximately 169 dB. The difference (5 dB) is required to offset the additional acoustic losses from sound absorption by the test article itself as well as by TPS insulation material installed on the test article.

The current vibro-acoustic test schedule requires that the orbiter aft section test article be delivered during the first quarter of CY 1978. The acoustic chamber must be operationally ready at that time to meet test requirements. To achieve that milestone, the modifications requested in this FY 1976 project must be initiated in early CY 1976, making FY 1976 programming necessary.

PROJECT DESCRIPTION:

This project provides for modifying the acoustic reverberant chamber of the VATF, Building 49, to provide an increased sound pressure level within the chamber of approximately 169 dB. The work includes procurement and installation inside the chamber of 24 acoustic horns and 20 noise generators, replacement of the interior chamber walls with stronger walls below the 30-foot level (9.1-m), and installation of a compressed gaseous nitrogen (GN_2) system. The new GN_2 system, necessary to operate the new noise generators, will require installing a new vaporizer, extending necessary steam lines to support the vaporizer, and providing a GN_2 distribution and recirculation system. An existing liquid nitrogen storage system will be used.

The project also provides for erecting sound retarding rooms around noisy test equipment within the existing vibration laboratory in order to meet noise criteria especially in relation to exposure of test personnel.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$1,840,000
Nitrogen supply and recirculation system	LS	---	---	1,118,000
Reverberant chamber structural modifications	LS	---	---	317,000
Electrical modifications	LS	---	---	95,000
Mechanical modifications	LS	---	---	260,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Vibration laboratory modifications	LS	---	---	$50,000
Equipment				$570,000
Noise generators	EA	20	$20,500	410,000
Acoustic horns	EA	24	6,675	160,000
Fallout Shelter (Not Feasible)	---	---	---	---
	TOTAL			$2,410,000

Noncollateral type support fixtures will be procured and installed from the R&D appropriation at an estimated cost of some $300,000. This equipment is closely associated with the test articles and is required to make the facility operational.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

For present planned usage, there are no currently foreseen future funding requirements necessary to complete this project.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

PROJECT TITLE	Modifications for Solid Rocket Booster Component Manufacturing and Assembly Facilities
LOCATION	Various Locations
	FY 1976 CoF ESTIMATE $3,000,000

COGNIZANT INSTALLATION: Marshall Space Flight Center

LOCATION OF PROJECT: To be designated

COGNIZANT PROGRAM OFFICE: Office of Manned Space Flight

FY 1975 AND PRIOR YEARS CoF FUNDING:

Planning and Design	$240,000
Construction	---
Total FY 1975 and Prior Years	$240,000

SUMMARY PURPOSE AND SCOPE:

This project provides for modifying existing facilities, at sites to be determined, for the manufacture and assembly of solid rocket booster (SRB) components. Facility requirements depend in part on the actual SRB contractor to be selected in the second quarter of CY 1975. Although a specific contractor or plant has not yet been selected for this work, facility modifications and their estimated cost have been determined on the basis of an engineering analysis related to this hardware, using Michoud Assembly Facility, New Orleans, as a "baseline."

PROJECT JUSTIFICATION:

The SRB consists of the two solid rocket motors and major structural components. The solid rocket motor contractor, Thiokol, has been selected; motor manufacture and assembly will be carried out in the contractor's plant near Salt Lake City, Utah. Shuttle program requirements include selecting, before mid-CY 1975, SRB contractor(s) to manufacture and assemble the major SRB components - the aft and forward skirts, the nose cone, the external tank/SRB attachment structures, and various brackets.

Major components range from 9 to 20 feet (2.7 to 6.1 m) in length and from 12 to 13 feet (3.7 to 4.0 m) in diameter. To produce these components modifications to existing manufacturing facilities are required. This project provides for the necessary facility modifications to carry out the work involved during the design, development, testing and evaluation (DDT&E) phase of the program.

Current program plans are based on the first manned orbital flight occurring in the second quarter of CY 1979. To achieve this major milestone, delivery of the first SRB test article is required in the second quarter of CY 1977. To achieve this goal, modifications for SRB component manufacturing facilities must be started during the fourth quarter of CY 1975; facilities must be operational by the fourth quarter of CY 1976.

PROJECT DESCRIPTION:

This project involves modifying approximately 190,000 square feet (17,651 m^2) of existing manufacturing and assembly facilities for the production of SRB components. These modifications are necessary to provide work stations especially tailored to the geometry, weight, and size of the individual SRB components to be manufactured. The work includes providing reinforced concrete foundations for tooling, relocating and extending utility systems, modifying the air conditioning system, relocating and rerouting overhead bridge cranes and railings, reinforcing crane and structural trusses, making minor modifications to the plant, and rearranging and upgrading the overall lighting system. The project also provides for procurement and installation of collateral equipment, including a heat treat oven, a cleaning booth, pumps, and a paint spray booth, that is essential to support the manufacturing operations.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				$2,700,000
Modification of manufacturing space	SF	190,000	$14.21	2,700,000
Equipment	---	---	---	300,000
Fallout Shelter (Not Feasible)	---	---	---	---
	TOTAL			$3,000,000

The project provides only for facility modifications which will provide the capability for assembling the SRB structural components. Special tooling and other noncollateral equipment required in the manufacturing and assembly operations, which are unique to the developmental vehicles and are not affixed to the facility, would be procured with the hardware itself and will therefore be provided for by Research and Development resources. A detailed cost estimate for this tooling and special equipment will not be available until the SRB contract has been awarded. It is intended, however, to make maximum use of the existing Apollo tooling, with modifications whenever feasible.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

Additional CoF resources may be required to support rate production beyond DDT&E. A precise estimate cannot be determined until a contractor is selected and the requirements are definitized.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

Rehabilitation and Modification

Summary of Project Amounts by Location	Amount	Page No.
FY 1976		
Ames Research Center	$1,565,000	CF 5-3
Goddard Space Flight Center	1,085,000	CF 5-5
Jet Propulsion Laboratory	1,345,000	CF 5-7
Johnson Space Center	1,400,000	CF 5-9
Kennedy Space Center	1,620,000	CF 5-11
Langley Research Center	1,610,000	CF 5-13
Lewis Research Center	1,255,000	CF 5-15
Marshall Space Flight Center	930,000	CF 5-17
Michoud Assembly Facility	465,000	CF 5-18
National Space Technology Laboratories	105,000	CF 5-18
Wallops Flight Center	830,000	CF 5-19
Various Locations	2,250,000	CF 5-20
Miscellaneous Projects Less than $100,000 Each	1,540,000	CF 5-22
Total, FY 1976	$16,000,000	
Transition Period July 1, 1976 - September 30, 1976		
Ames Research Center	600,000	CF 5-26
Goddard Space Flight Center	660,000	CF 5-26
Jet Propulsion Laboratory	800,000	CF 5-27
Johnson Space Center	300,000	CF 5-28
Kennedy Space Center	430,000	CF 5-29
Langley Research Center	770,000	CF 5-29
Lewis Research Center	600,000	CF 5-31
Marshall Space Flight Center	470,000	CF 5-31
Michoud Assembly Facility	225,000	CF 5-32
National Space Technology Laboratories	210,000	CF 5-32
Wallops Flight Center	200,000	CF 5-33
Various Locations	2,535,000	CF 5-34
Miscellaneous Projects Less than $100,000 Each	950,000	CF 5-39
Total, Transition Period	$8,750,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

PROJECT TITLE	Rehabilitation and Modification of Facilities Not in Excess of $500,000 Per Project	
LOCATION	Various Locations	
		FY 1976 CoF Estimate $16,000,000
FY 1974 $14,785,000		FY 1975 $14,900,000

COGNIZANT INSTALLATION: Various Locations

LOCATION OF PROJECT: Various Locations

COGNIZANT PROGRAM OFFICE: Office of the NASA Comptroller

SUMMARY PURPOSE AND SCOPE:

This program is intended 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 1976 which can be foreseen at the time of the submission of these estimates, and which are estimated to cost not in excess of $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 insure the continued safe, economical, and efficient use of these physical plants. While, in the past, this particular program has been specifically directed toward the general nonprogrammatic segments of NASA facilities, this is the fourth year in which additional attention has been given to facility modification requirements generated by specific programs or projects.

PROJECT JUSTIFICATION:

At its initial cost, the existing NASA physical plant totals about $5.9 billion (June 30, 1974). A continuing program of rehabilitation and modification of these facilities is required to:

a. Protect the capital value represented by those facilities and to overcome the cumulative effects of wear and deterioration.

b. Insure 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 to overcome the aggregate effects of obsolescence.

d. Provide a better and safer environment for all personnel.

e. Prepare for more efficient energy utilization by updating and improving utility systems.

This project includes only facility rehabilitation and modification 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 which 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 of facilities projects (new and addition type) required in FY 1976. These latter requirements for FY 1976 are provided for under a separate project entitled "Minor Construction" which are included in these estimates.

PROJECT DESCRIPTION:

Items of rehabilitation and modification proposed to be accomplished within this program for FY 1976 are outlined under "PROJECT COST ESTIMATE" and total $16,000,000. Of this total $14,460,000 is represented by discrete work packages at designated NASA installations. The remaining $1,540,000 relates to those smaller rehabilitation and modification projects estimated to cost less than $100,000, the nature and purpose of which are the same as for that work specifically delineated but which, because of their individual smaller size, are not listed by item. At this time these items are considered to be of the highest priority. They have been carefully selected from lists totaling about $45 million. The $16,000,000 listing represents a most 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.

The remainder of the rehabilitation and modification work should be undertaken as a phased program over the next several years to place these installations on a more economical and efficient operating base. 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 and 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 $14,460,000 of discrete projects relates to the following broad categories of facilities:

a.	Utility Systems	$2,575,000
b.	Fire Detection/Protection Systems	745,000
c.	General Purpose Buildings	3,080,000
d.	Technical Buildings/Structures	7,550,000
e.	Pavements and Drainage	100,000
f.	Building Exteriors and Roofs	410,000

In addition there is the "Lump Sum" estimate of $1,540,000 for smaller project work, thus making a total of $16,000,000. The FY 1976 requests for facility rehabilitation and modification work, therefore, are directed toward the most urgent current needs for work of this type in the continuation of this essential program at NASA installations.

A. Ames Research Center $1,565,000

1. Rehabilitation and Modification of Unitary Wind Tunnel Subsystem, Building N-227 385,000

This project provides for rehabilitation and upgrading of the automatic model support system and associated position control systems in the 8 X 7 Foot (2.4 x 2.1m) Wind Tunnel main drive compressor, replacement of the rotor blade shrouds in the 11-by 11-Foot (3.3 X 3.3m) Wind Tunnel main drive compressor, and modification of the cooling tower to prevent steam/water vapor drift. These facilities are all part of the Unitary Wind Tunnel Complex, a 19-year old facility costing about $33 million. It normally operates 24 hours a day in support of DoD, commercial transport, and NASA research programs, including space shuttle. The model support system rehabilitation will provide increased capacity, reliability and safety, and increased drive rate capability for angles of yaw and attack. This work has become necessary because gradual wear and deterioration of existing components have increased maintenance requirements and tunnel shutdown while reducing allowable test load capacity. The work will restore full load capability and significantly reduce the average tunnel operational hours required to reach test objectives, with substantial man-hour and electrical energy savings. Existing rotor blade shrouds have over 10,000 hours of operation; undiscovered failure could lead to blade loss during operation with probable extensive damage to the facility. The cooling tower rehabilitation will replace present vapor drift eliminators

with new improved units which will eliminate corrosion and vapor damage to nearby metal buildings and vehicles, as well as save up to 50,000 gallons (189.3 KL) of water in each eight hours of operation.

2. Rehabilitations and Modifications for Fire Protection $225,000

This project provides for the installation of fire detection equipment in twenty two buildings. These modifications will also include the coversion of the existing 7 X 10-foot (2.1m X 3.0m) No. 1 Wind Tunnel drive motor fire protection system from manual to automatic activiation with the installation of temperature detector automatic discharge valves and controls and equipment shut down interlocks. Also included is the rehabilitation of six other existing Wind Tunnel drive fire protection systems, including overhaul or replacement of valves, compressors, detectors, and relays as required. The 7 X 10-Foot Wind Tunnel No. 1 drive fire protection system is inadequate and it is unlikely that the existing manual system could be activated in time to limit damage in case of fire. The six other Wind Tunnel drive protection systems must be tested, repaired or modified to significantly improve reliability.

3. Rehabilitation and Modification of Flight Project Facility, Building N-244 105,000

This project consists of modification of approximately 1,700 square feet (153 sq.m) of interior space of Building N-244. The work consists of adding partitions, doors, a ceiling, flooring and the necessary heating, air conditioning and electrical to an existing mezzanine to provide a shop/laboratory and a small equipment/tool storage area. A 4 X 6 foot (1.2 X 1.8m) 1,500 pound (680 kg) equipment lift is provided to transport the project equipment to the mezzanine. A moveable roof and a heavy steel blast door are being added to the existing exterior hydrogen test area. This is required to provide the space and environment necessary to do the assembly and testing of the control and experimental instrumentation and recovery package for spacecraft payload integration work. In future years the mezzanine may be further extended to provide additional laboratory space.

4. Acoustic Modification to 7-by 10-Foot Wind Tunnel #1, Building N-215 400,000

This modification will provide 15,000 ft^2 (1,389 m^2) of acoustically absorbent walls and baffles in one of the cross legs, the diffuser, and the test section of the 7-by 10-Foot (2.1 X 3.0m) Wind Tunnel #1. The test section walls will be removable so that the facility can be operated with acoustically treated walls, hard walls, or an open section. The diffuser inlet will be modified for operating in the open mode. This project also includes a closed circuit TV system, an air supply noise attenuator, and

miscellaneous relocation of existing mechanical and electrical items. The facility will be used by the Ames staff and Ames-Stanford Joint Institute for Aeroacoustics for studies of noise generating mechanisms in small-scale fans, full-scale airframe components and moderate-scale V/STOL propulsion systems. Basic problems to be studied include the effects of forward speed on noise generated by turbulence, and the study of noise generating mechanisms typical of the more complex V/STOL aircraft. This research will materially contribute to the timely attainment of objectives and targets in aircraft noise abatement by making it possible to predict aircraft noise, and to design aircraft having noise output within limits that are safe for, and acceptable to the public. The proposed modification will be permanent and economically usable for the life of the wind tunnel. There are no other future related modifications anticipated for this facility.

5. Rehabilitation and Modification of First Floor Central Labs of Flight Simulation Laboratory, Building N-210 $450,000

This project provides for the modification of approximately 11,000 square feet (990 sq. m) of space in the high bay of Building N-210 into four (4) large simulation laboratories. The work involves the addition of partitions, doors, ceilings, computer access floor, painting, new heating and air conditioning systems, providing adequate rest room facilities, lighting and electrical power systems as well as rehabilitation of the building's chilled water system. This project will provide the space necessary to house special computer and related hardware for simulation support of the Center's new flight projects, such as V/STOL, Tilt-rotor, Augmentor-wing aircraft, etc. This first floor modification will be structurally designed to accommodate a future second floor.

B. Goddard Space Flight Center $1,085,000

1. Modification of Fire Protection Systems 420,000

This project provides for the installation of automatic sprinkler systems in the following 15 laboratory and test buildings to protect life, safety of personnel, high value equipment, and spacecraft components:

a. Magnetic Test Facility, Buildings 302, 303, 304, 305 - These buildings are used for spacecraft testing and frequently housed flight hardware.

b. Main Gate House, Building 9 - This is a security office and has below-grade occupancy creating difficulty in fire fighting.

c. Mechanical Test Facility and Quality Assurance Laboratory, Building 22 - This facility has a complete system of radiation-affected areas which are also below-grade for occupancy.

d. Magnetic Quiet Test Facility, Buildings 306, 307 - These buildings are unique test facilities and frequently house flight hardware.

e. Development Operations, Building 16A - This building houses a high volume of paper operations consisting of employee records, shipping and receiving of documents. Revised life safety criteria for this type structure and occupancy indicate sprinkler protection is required.

f. Central Heating and Refrigeration Plant, Building 24 - This building houses the center's control power plant and a backup diesel facility which is a critical facility during manned and unmanned missions.

g. Chemical Propulsion Facility, Buildings 402, 407, and 414 - This facility has unique high value, one-of-a-kind equipment involved in development and testing of flight hardware.

h. Space Science Laboratory, Building 6 - This building houses the center's reliability and quality assurance facility including unique one-of-a-kind high value test and diagnostic hardware.

i. Multi-Purpose Building 17 - This building houses network support data and communications equipment.

Prior year funding at Goddard for these general types of fire protection and safety items totals $2,986,000. Future funding of this type work is now estimated at approximately $3,000,000 and this would be progressively accomplished on a priority basis over several years.

2. Modification of Data Interpretation Laboratory, Building 23 $175,000

This project provides for the modification of approximately 6,000 square feet (552 m^2) on the ground floor of Building 23 for the installation of the new input processor, storage and management information system. Modification work will include all electrical, mechanical and environmental interfaces. This telemetry on-line processing system (TELOPS) is needed to (a) support experiments from operationally complex spacecraft in near real time, (b) improve facility efficiency and decrease operational costs by eliminating tape handling problems and reduce the time delay between data acquisition and data availability to experiments, (c) implement an efficient interface with the STDN network and eventually with the Tracking and Data Relay Satellite Systems (TDRSS), and (d) provide sufficient capability to handle the data volume expected in the future.

3. Modification of Heating, Ventilating and Air Conditioning Systems in the Network Test and Training Facility, Building 25 $490,000

This project provides for the conversion of the Network Test and Training Facility, Building 25, environmental control system from packaged direct expansion systems serving separate zones to a central chilled water system. This modification work is necessary since the existing direct expansion air conditioning package units have deteriorated to the point where they are now unreliable and require continual maintenance. The proposed conversion to a central chilled water system will not only improve the overall reliability of the plant but will effect considerable operating economies in reduced maintenance costs and energy conservation.

C. Jet Propulsion Laboratory $1,345,000

1. Modification to Environmental Laboratory, Building 144 490,000

This project provides for the modification of Room 100 in Building 144, to convert it to a class 10,000 clean room standard in accordance with flight project environmental needs. The work includes the application of clean, firm, smooth synthetic panels to all walls and ceilings, construction of a large airlock adjacent to the large access doors to Room 100, removal of the existing air handling system, installation of larger air handlers on the roof in conjunction with a filter bank and revised intake/exhaust duct work installation. Sealing, cleaning, and painting of the area is required. Change rooms for test personnel are included to make the complex functionally complete. This modification work is necessary since Room 100 of Building 144 is presently lined with open, fibrous, board-type sound absorbing panels to deaden the noise from a large electrodynamic shaker. The panels cannot be cleaned because of their cellular construction and continue to absorb quantities of dirt whenever the main access doors are open. Shaker operation causes extensive dusting of the panels in violation of flight project cleanliness criteria. Limited control has been obtained through the use of "clean" tents, but the scope of future missions makes further use of tents impractical. A permanent solution is desired to control contamination in the dynamics laboratory. Conversion of the air conditioning system to filtered, diffused, vertical down flow system will complete the clean up.

2. Rehabilitation of Structural Test Laboratory, Building 18 295,000

This project provides for the replacement of nine individual air conditioning units, a boiler and space heaters in Building 18 with a central circulating water system. The new air conditioning system

will handle both heating and cooling requirements. It will include necessary ducting, diffusers, filters, controls and balance appropriate to the complete heating, ventilating and air conditioning system. Interior lighting and electrical circuits will be improved and limited interior cleanup, compatible with the modification is provided, including rest room upgrading. The construction of this building dates back to 1951 with improvements in 1958 and 1963. Most replacement parts for the nine separate obsolete air conditioning units, plus space heaters which condition the interior, are no longer available. Breakdown rate is high and maintenance of 20 to 25-year old surplus equipment is no longer economical. Review of heating, ventilating and air conditioning maintenance costs show we are spending three times the replacement cost every four years for many of the air conditioning units in Building 18. Electrical panels are overloaded, and all older lights are without ballasts, leading to excessive burn out.

3. Rehabilitation of Electrical Safety Connections $185,000

This project provides for the replacement of electrical power receptacles in all JPL facilities at Pasadena to effect compliance with safety requirements using National Electrical Manufacturers Association (NEMA) standard devices which will permit interconnection of new equipment, which is manufactured in accordance with the new NEMA standards, with existing system. This project is required to enable installation of new spacecraft supporting equipment and also provide for personal safety.

4. Rehabilitation and Modification of Space Flight Operations Buildings 230/264 375,000

This project provides for the following modifications within the Buildings 230/264 Control Complex to meet operational requirements for the Mariner Jupiter Saturn (MJS) mission.

a. Mission Support Area: This work includes partition changes, electrical modifications, equipment rearrangement, installation, checkout/integration in Buildings 230/264. The Mariner Jupiter Saturn (MJS) project requirements specify the need for a completely equipped and checked out Mission Support Area (MSA) by January 1, 1977. Even if there is no extended mission on Viking, the Viking project cannot release any Building 230 space to MJS earlier than November 30, 1976, which leaves only one month to accomplish the necessary modification work. Therefore, it is planned to develop a separate MSA for MJS 77.

b. Telemetry Mini Computer Area: This work includes modifications to the existing telemetry system. Viking constraints on the present system dictate the need for development of a new real time telemetry system for MJS to support the initial training and flight operations.

c. Safety Tasks: This work includes rehabilitation of the boiler and cable way systems in accord with recommendations resulting from recent safety inspections. A boiler stack is deteriorating to the point of being in danger of exuding carbon monoxide into the building and therefore must be repaired in the near future. All new cable ways through the floors are built to the new fire regulations but existing cabling requires correction by installation of approved fire stops.

D. Johnson Space Center $1,400,000

1. Modifications to 11-Foot (3.4m) Chamber, Building 7 160,000

This project provides for removing the existing Lunar Module (LM) cabin section and the installation of a flange to allow acceptance of the Space Shuttle Environmental Control and Life Support System (ECLSS) "boiler plate" (orbiter crew cabin) at one end of the existing 11-foot chamber. The work includes installing a new flange and providing all necessary utilities and fire suppression and safety equipment. The instrumentation, data acquisition, operational support equipment, and fully trained operating crews for conducting tests in this facility are already available. This project is essential to assure that the space shuttle ECLSS hardware is evaluated under realistic test environments and that hardware operational procedures can be verified under actual use conditions.

2. Rehabilitation of Chamber A Test Article Support Data Circuitry, Building 32 110,000

This project provides for replacing deteriorated electricial circuitry, including cables and terminal connectors, in Vacuum Chamber "A" of the Space Environmental Simulation Laboratory, Building 32. The work includes replacing data cables that are between the rotating lunar plane in the chamber and the terminal cabinet beneath the chamber, cleaning terminal connectors, and replacing the connectors on the lunar plane. The work will restore the support circuitry to its original full measurement condition to provide the data needed for evaluating space shuttle development. The existing data cables were installed in 1965, and have been used extensively to support all major Chamber "A" tests. For the past several years, increasing numbers of circuits have failed. This situation must be corrected since all circuits are required for the scheduled space shuttle vehicle tests.

3. Rehabilitation of Central Heating and Cooling Plant and Distribution Systems 210,000

This project provides for rehabilitating a portion of the steam and chilled water generating and distribution systems in the Central Heating and Cooling Plant, Building 24, and in the utility tunnel. The work includes the rehabilitation of the steam boilers, instrumentation, and

auxiliary equipment; the replacement or rebuilding of approximately 80 condensate and steam control valves; the replacement of steam and condensate expansion joints with expansion loops where possible; the rehabilitation of the chiller system, instrumentation, and auxiliary equipment; the repair and/or replacement of approximately 40 chilled water valves; and the rehabilitation of the cooling tower structure and systems.

This is part three of a five-year program of rehabilitation of the Central Heating and Cooling Plant and distribution systems. The systems have been in continuous operation since 1963. A recent survey disclosed that 75 percent of the valves in the chilled water system failed to close completely. There have been several system failures in the steam system. Boiler rehabilitation to the tubes and firebox is necessary at this time to prevent further deterioration, which would necessitate complete replacement. A major failure of this heating and cooling system could possibly result in a delay in mission-essential testing.

4. Modifications for Life Sciences Facility, Building 37 $420,000

This project provides for the phase II modifications of the Lunar Receiving Laboratory (LRL), Building 37, to permit its effective use as a life sciences facility. Presently, one-half of the usable space in the LRL is occupied by life sciences activities. The reconfiguration of the LRL to a complete life sciences facility will provide the necessary capability to further develop biomedical research and to support the life sciences payloads for the shuttle orbital flight and other programs. The medical and biomedical operations are presently scattered in several locations at JSC and Ellington, AFB. The FY 1975 phase I modification work consisted of converting the existing biological barrier air conditioning systems to conventional systems typical of other laboratories at JSC, modifying the air conditioning system in the administrative area, and providing required emergency access-ways through existing biological barrier areas. These phase II modifications will convert the former lunar sample laboratories into biomedical research laboratories, including cardiovascular, environmental physiology, neuroscience, and vestibular laboratories. The work includes removing existing built-in laboratory equipment, relocating partitions, and modifying air conditioning and utilities. This proposed project, when complete, will provide space for operations coordination, payload configuration, and integration and simulation for payload development and actual flight. The future phase III modifications will maximize the beneficial utilization of the LRL for life sciences payload and other activities.

51-423 O - 75 - 37

5. Replacement of Primary Electrical Feeders $240,000

This project provides for replacing the deteriorated 15 KV underground power cable for electrical circuit 1-11 and the electrical cable in the Center Support Area. The work includes replacing the existing 15-KV underground cable from "Oil Switch 300" to the switchgear in each of the buildings in the Thermochemical Test Area, and from "Oil Switch 400" to the switchgear in each of the buildings in the Center Support Area. This is phase II of a five-year program to replace these deteriorating cables, thus removing the potential of power failures which could adversely affect tests or other activities supporting the space shuttle and earth resources programs.

6. Modifications for Central Film and Tape Storage Area, Building 228 160,000

This project provides for modifying existing Building 228 for use as a central photographic film and computer tape storage area. The work includes upgrading existing fire detection, alarm, and suppression systems to meet all established fire protection standards and codes; modifying the air conditioning system, installing a new cold storage vault for tape and film; and installing movable and stationary storage units. The project is required: to eliminate the present fire hazard involved in housing computer tapes near computers; to alleviate congested storage conditions; and to afford maximum storage protection.

7. Rehabilitation of Photographic Hardware Development Laboratory, Building 15 100,000

This project provides for various office and laboratory area modifications to accommodate the consolidation of the functional elements of a photographic systems development laboratory. The modifications include partition relocations and associated electrical, telephone outlet, and air conditioning modifications. A recent reorganization of two directorates consolidated, within a single engineering and development organizational segment, a combined photographic systems development laboratory which performs the tasks of system development and optical system test, calibration, and repair in support of spacecraft and Earth Resources programs. The laboratories and other functional areas to be consolidated include a clean room facility, a bonded storage area, a darkroom, a photographic and crew operational hardware verification test area, a photographic systems laboratory, a design laboratory, and a small decal laboratory.

E. Kennedy Space Center $1,620,000

1. Modification of Chilled Water System, Operations and Checkout Building, Building M7-355 240,000

This project provides for modifying the existing chilled water system in Building M7-355 to allow the total chilled water requirement

to be satisfied by the east equipment room only. Work includes installing approximately 1,600 feet (488 m) of 16-inch (41 cm) insulated, welded pipe between the east and west equipment rooms. It also provides for installing three 1,065-gal/min (4,031-liter/min) pumps, and making the necessary electrical and building modifications. This project will reduce operations and maintenance costs, conserve electricity and release chiller equipment for other requirements.

2. Modification of Air Conditioning System, Utility Annex Building, Building K6-947, Launch Complex 39 $395,000

This project provides for moving one 970-ton chiller and associated switches from Building M7-355 to Building K6-947 at Launch Complex 39. Work will include making electrical modifications and condenser and chilled water connections, and providing remote operation controls and readout instrumentation. Necessary pumps will also be installed. The modifications will result in a significant electrical energy savings by using the 970-ton chiller in lieu of operating a second 2,500-horsepower unit to satisfy peak load requirements as is presently done.

3. Rehabilitation of High Temperature Hot Water System, KSC Industrial Area 490,000

This project provides for rehabilitating 4,700 feet (1,433 m) of underground hot water supply and return lines by installing the lines above ground and providing new insulation and protective jacketing. It also provides for rehabilitating associated valves and sleeves. Rehabilitation of this system is necessary to reduce major heat losses. Significant energy savings (fuel oil) per year are anticipated upon completion of this project.

4. Rehabilitation of Elevators on Mobile Service Towers, LC 36 "A" and "B", Eastern Test Range 330,000

This project provides for major rehabilitation of one elevator on each of the two mobile service towers on Launch Complex 36 to provide reliable elevator service for personnel during assembly, checkout, and launch of the Atlas-Centaur missions scheduled for launch from LC-36 through 1979. The existing elevators, which have been in service over 10 years, have deteriorated from heavy use and exposure to salt air.

5. Rehabilitation of Utilities in the Communication Building, Building M6-339 and KSC Headquarters Building, Building M6-399 165,000

This project provides for the rehabilitation of the air conditioning system in the Communications Building, Building M6-339 by replacing the

present air-distribution system with a supply-air duct system and rebalancing the system. Damaged acoustical ceiling panels throughout the building will be replaced. The original air conditioning system was designed for a large open office area, which has since been partitioned. The present system has an insufficient air discharge area resulting in wide temperature variations, and insufficient air circulation. The project also provides for the rehabilitation of the hot water system in the KSC Headquarters Building, Building M6-399 film processing room. The work includes replacing the existing inadequate electric water heaters with two large hot water exchangers and associated equipment. Approximately 2,000 feet (609.6m) of insulated supply and return piping to the film processing room will be installed.

F. Langley Research Center $1,610,000

1. Rehabilitation of High Pressure Air Facility, Building 1247E 370,000

This project provides for rehabilitation and modification to the 5,000 psi (34,475,000 n/m^2) and 6,000 psi (41,370,000 n/m^2) central compressor station. Included in the modifications is the construction of a sound-resistant control room which will incorporate a console with indicators for monitoring pressures and temperatures of the compressed air, cooling water, lube oil and bearings of the five (5) large compressors by the use of remote sensing devices. This control room will provide a low noise level environment for facility operators during the major portion of their duty hours, thereby ensuring compliance with Occupational Safety and Health Act (OSHA) Standards with respect to high noise levels. Rehabilitation of the building interior includes minor repairs to the walls, floor and ceiling, improvement of the building ventilation system, some new light fixtures, and improved building power supplies. The exterior work includes minor repairs to the walls and windows, exterior pedestrian doors, exterior service doors and the roof. Facility 1247E was originally constructed in 1952 and repairs to flooring and ceiling are required in various areas. The walls and windows have been damaged by equipment vibration. New light fixtures are needed to meet current standards. Several recent studies have indicated that the operators are subjected to noise levels in excess of the limits allowed by current federal regulations. The compressors are so large that it is impractical to isolate them and it is more economical to shield the operators by building a sound-resistant control room. The main part of the building has an average noise level of 89 db with some areas up to 108 db.

2. Rehabilitation of the Unitary Plan Wind Tunnel, Building 1251 490,000

This project provides for the rehabilitation and replacement of critical research equipment in the Unitary Plan Wind Tunnel, Building 1251.

A remote monitoring system for the main drive and make up air systems will be installed to eliminate the need for personnel operating in a machinery generated noise environment in excess of OSHA Standards, thereby resolving a serious safety problem. Worn out equipment such as the cooling water pumps, the 3,500 horsepower motor gearbox coupling, the 63,000 horsepower main drive motor fans and rings, the hydraulic pumps, the air dryer system valves and the stagnation control vacuum valves will be replaced. Various facility components of this unique 19-year old facility have deteriorated extensively thereby not only causing, for the present, numerous unscheduled repairs, but also becoming the cause for an extended termination of operations in the near future unless complete rehabilitation of the affected parts is accomplished. Recently the primary mission of this facility has been to assist with the development testing of the critical boost and reentry phases of the space shuttle. Research and Development programs of NASA, DoD, and industry in the development of high speed aircraft and missiles require continuous support from this facility. Future funding requirements are about $3.8 million.

3. Rehabilitation of Electrical Power Distribution System, 22KV $450,000

This project provides for the replacement of major elements of the Center's electrical power distribution system at the 22,000 volt level. Included are 2 three-phase 7,500 KVA transformers and 2,500 feet (762 meters) of power feeders. Associated with the above work are minor modifications to system relay devices and miscellaneous duct and sub-station hardware to integrate the new transformers and feeders.

This upgrading of the system components will ensure continued uninterrupted service to 12 research and institutional facilities located in the East and West Areas and to the U.S. Air Force facilities served from this distribution system. The power transformers which were originally installed in the East Area in 1935 were relocated in the 1940's during the initial West Area expansion. Also the cables which were originally installed in the East Area in 1937 were moved to serve areas in the expanding West Area. Transformer obsolescence and inability of manufacturers to furnish spare parts makes maintenance and repair of this equipment most difficult. The cable insulation age and sheath deterioration have been a cumulative factor in further decreasing dependability of the systems.

4. Rehabilitation of Freon Reclamation System - Transonic Dynamics Tunnel, Building 648 200,000

This project provides for the replacement of the refrigeration state in the Freon-12 Reclamation System for the Transonic Dynamics Tunnel. Other equipment replacement required to restore the 20-year old, 35-ton, 3-stage unit to its originally designed capacity includes heat

exchangers, condensers, valves and interconnecting piping. Since the system operates below its design performance, an annual Freon-12 loss of $42,000 is experienced; hence, the project will effect an energy savings in Freon gas which will amortize the project cost in approximately five years. The Transonic Dynamic Tunnel is a unique national facility designed specifically for study of aeroelastic problems covering flutter, buffeting, ground wind loads and gust loads. It is used for support of such national programs as Space Shuttle and Viking with appropriate in-house studies, and to perform flutter clearance studies on the B-1 and YF-16 aircraft.

5. Rehabilitation of Hangar Addition, Building 1244D $100,000

This rehabilitation project will upgrade the reconstructed hangar addition, Building 1244D. This work will include additional electrical power, lighting utilities, and installation of fire sprinkler systems to provide storage and work space in support of the aeronautics research program. The existing hangar addition is a prefabricated structure which has been moved twice and reerected. The structure was approximately 16 years old when it was brought to Langley from Travis Air Force Base. The work is needed as soon as possible to provide more advantageous use of the available space. Some additional modifications will be required to this hangar in future year's programs.

G. Lewis Research Center $1,255,000

1. Rehabilitation of Exhaust System Safety Devices for Propulsion Systems Laboratory (PSL) Equipment, Building No. 64 390,000

This project will provide for the rehabilitation by replacement of seven 54-inch to 84-inch (136cm to 211cm) hydraulically operated butterfly valves in the exhauster system with check valves equipped to operate by air. The seven check valves will provide overpressure protection by operating at approximately 1 to 2 p.s.i. (0.7-1.4n/cm2) thereby preventing overpressure at the inlets of the 2nd, 3rd, or 4th stage exhausters. The new check valves will control the air flow through the system to relieve an overpressure hazard. The check valve operator will contain a shear pin to provide additional safety provisions. A recent hazard analysis of the PSL exhaust system at Building 64 has indicated the need for this positive means of overpressure protection.

2. Rehabilitation of Refrigeration Building No. 9 240,000

This project provides for the rehabilitation of the Refrigeration Building No. 9. The rehabilitation of the exterior will include repairs to the roof, flashings, parapets, tuck point and waterproofing the masonry, and the replacement of the existing windows. The interior rehabilitation includes the strengthening of the existing wood trusses

with metal tie rods, and painting of the interior surfaces. The Refrigeration Building No. 9 was constructed to minimum standards with World War II materials. Ordinary wear and tear over the years has resulted in degradation of the quality of the interior and exterior surfaces to the point where complete rehabilitation is needed to improve the building and resist further deterioration.

3. Rehabilitation of Petroleum-Chemical Air Heater No. 2, PSL Equipment Building No. 64 $270,000

This project provides for the rehabilitation of the 17-foot (5.2m) diameter 45-foot (13.7m) long gas fired petroleum-chemical Air Heater No. 2 in the PSL Equipment Building No. 64. The interior tube framing system and tubes will be rehabilitated by replacement. This heater is required to be rehabilitated to provide the required quantity and temperature of heated combustion air for testing larger jet engines with high subsonic air flow. The present two petroleum-chemical heaters are inadequate to supply the demand. Rehabilitation of this heater will result in increased operational efficiency.

4. Rehabilitate Combustion Air Intercoolers in Engine Research Building No. 5 185,000

This project will provide for the replacement of the 14 existing combustion air intercoolers located in the Engine Research Building (ERB) No. 5 with new intercoolers and associated piping. These 14 remaining ERB combustion air compressors intercoolers must be replaced so that an acceptable compressed air quality for research programs can be maintained. In 1970 an initial 11 intercoolers were replaced. These remaining coolers are now approximately 30 years old and leak cooling tower water into the air system. This leakage acts as a damaging contaminant producing loss of research data and sometimes damage to instrumentation and other equipment. Center energy consumption will be reduced with the increase in efficiency of the proposed new coolers and piping as less power is required to operate the compressors and water pumps.

5. Rehabilitate Library Service Building No. 60 170,000

This project provides for the rehabilitation of approximately 58,000 square feet (5,390 m^2) of the Library Service Building, No. 60. The rehabilitation of the exterior includes repair of the roof, flashing and parapets, tuck pointing, cleaning, water proofing masonry, and caulking all stone work joints. New aluminum windows will be installed on three floors. This building was constructed in 1951 and has been in continuous use. The rehabilitation of the exterior will bring this building up to current standards.

H. Marshall Space Flight Center $930,000

1. Modifications for Software Test and Integration Laboratory (STIL), Building 4708 100,000

This project provides for the necessary modifications in Building 4708 to accommodate the Spacelab Software Test and Integration Laboratory. The modifications cover a floor area of approximately 8,500 square feet (782 m^2) of computer laboratory and office space. Proposed modifications include installing partitions; installing heating and air conditioning and electrical power systems. The STIL, which will consist of a large computer (IBM 370 class) and a spacelab data management computer system, will be used to verify spacelab software provided by the European Space Research Organization (ESRO) and to develop, produce, and verify software for the operational phase of this program. It will further be used to maintain and update spacelab software and to integrate the collective experiments applications software for spacelab mission.

2. Modification of Space Sciences Laboratory, Building 4481 480,000

This project constitutes phase five in the improvements program for Building 4481. It provides for modifying approximately 9,000 square feet (828 m^2) of floor space and some exterior work. The interior work involves replacing partitions, doors, frames, and ceilings; and the heating, cooling, ventilating, lighting, electrical, plumbing, and safety systems. The exterior work involves adding windows and modifying the entrance. The purpose of this project is to provide adequate housing for scientific personnel and to eliminate the crowded conditions, inadequate power, poor humidity and dust control, and low water and air pressure which have hampered research.

3. Rehabilitation of Air Conditioning System, Data Systems and Test Building, Building 4708 350,000

This project provides for rehabilitating air conditioning systems serving approximately 40,000 square feet (3,680 m^2) of floor space on the south side of Building 4708. Eight individual direct expansion-type air conditioning systems will be replaced by a centrifugal water chiller system with a 600-ton capacity. Systems to be modified will incorporate provisions for energy conservation. A recent study of energy utilization of Building 4708 indicated that this project would significantly reduce annual electrical consumption and annual industrial water consumption. This project is the first of three phases involving the rehabilitation of all of the air conditioning in Building 4708. This project will alleviate maintenance problems created by the varying size and type of existing systems, and will reduce consumption of electrical power approximately 500,000 KWH and 30 million gallons of water (113,600 KL) annually.

I. Michoud Assembly Facility $465,000

1. Modification of Utilities Monitoring Systems, Manufacturing Building 103 and Engineering Buildings 101 and 102 315,000

This project provides for modifying the existing plant utilities monitoring system by adding controls for the 51 fan houses and two equipment rooms atop Buildings 101, 102, and 103. This addition will decrease response time for starting and stopping a 30-horsepower blower and a 20-horsepower chilled water pump in each of the 51 fan hours. In addition, it will provide for closer maintenance of plant environment and significantly reduce consumption of electric energy.

2. Rehabilitation of Manufacturing Building, Building 103 $150,000

This project provides for rehabilitation of three large access doors on the west end of the Manufacturing Building 103. Each of these doors is 120 feet wide by 40 feet high and weigh about 75 tons. The doors rise upward and fold for a clear opening and are powered by heavy motors for complete mechanization. The doors are 30 years old and require major refurbishment to preclude interruption or shutdown of the external tank production flow once manufacturing begins. The rehabilitation work will include replacing some of the tracks, gaskets, cables and bearings; refurbishing the electrical system, including the motors, limit switches, relays, and contactors; and replacing all necessary parts to insure that the doors are watertight.

J. National Space Technology Laboratories $105,000

1. Replacement of 150-Ton Absorption Chiller Unit, Material Receiving and Storage Facility, Building 2204 105,000

This project provides for replacing the existing 150-ton absorption chiller unit, which supplies the temperature and humidity environment for critical storage areas, and making necessary repairs to the high temperature hot water circulating pump. Replacement parts are no longer available for the absorption unit, and it has become impractical and uneconomical to continue making replacement parts in-house.

K. Wallops Flight Center $830,000

1. Rehabilitation of Electrical Facilities 245,000

This project provides for the rehabilitation of the overhead distribution system in the rocket storage area, replacing wooden platform substations with structural steel and new transformer banks at E-134, F-20 and F-21 and replacing existing wooden poles with concrete standards at launch pads 0, 2, 3, 4 and 5. The present distribution system is approximately 30 years old and in a state of serious deterioration. The system should be rebuilt to alleviate major outages and excessive maintenance.

2. Rehabilitation of Aircraft Maintenance Hangar, Building D-1 435,000

This project provides for the rehabilitation of the building exterior to include removal and replacement of 17,500 square feet (1,626 square meters) of built-up roofing, replacement of all north wing windows, replacement of 18 exterior doors and 12 doors between the hangar bay and wings, replacement of the roll-up door, weatherstripping the sliding hangar doors, patching the stucco, and painting the entire exterior. The interior rehabilitation shall include removal of 19 existing window units from the north wing second floor offices and installation of a central air conditioning system, renovation of the first floor heating system, painting the first floor shops, replacing the light fixtures in the first floor shops, replacing the air compressors, replacing the domestic water system, and renovation of all rest room facilities. This rehabilitation is required to minimize further deterioration of this building and to correct deficiencies in the Heating Ventilation and Air Conditioning (HVAC), electrical and plumbing systems.

3. Rehabilitation of Automotive Repair and Utilities Maintenance Building F-20, and Electric and Carpenter Shop Building F-21 150,000

This project provides for the rehabilitation of buildings as follows:

a. Building F-20: This work includes rehabilitating the air conditioning unit for the office area, and installing grease trap and related piping in the building drainage system, rehabilitating the building heating system, upgrading the rest room ventilating system, and replacing the fixtures. Providing supplemental lighting and power and upgrading the truck exhaust system. Rehabilitating service doors and resealing the roof joints to prevent leakage.

b. Building F-21: This work includes providing a new air conditioning unit for the office area, rehabilitating the building heating system, upgrading the rest room ventilation system and replacing fixtures. Providing supplemental lighting and power. Rehabilitating four service doors and resealing joints to prevent leakage.

The work to be done in the above buildings is urgently required to prevent further deterioration and to provide a suitable working environment.

L. Various Locations $2,250,000

1. Rehabilitation of Primary Transfer Switches, Downey, California 100,000

This project provides for upgrading one 15kV drawout switch unit and for providing 32 existing 15-kV switch units with new arc chutes. It also provides for adding discharge spring latches and for the modification of 16 transfer switch enclosures by weatherproofing, installing filters, and installing heaters and controls. These repairs and modifications are necessary to prevent future failures which could cause power interruptions and have an adverse impact on the shuttle program.

2. Rehabilitation and Modification of NASA Industrial Plant, Santa Susana, California 450,000

This project provides for replacing the existing deteriorated underground water piping serving the "Alfa" test stands with approximately 1,800 feet (548.6 m) of 24-inch (61-cm) carbon steel pipe and related valving above ground. This water system is used primarily for fire protection and flame-deflector cooling for the "Alfa" test stands, which are being used to test the smaller rocket engines. These engines cannot be reliably and economically tested with the current breakdown experienced with the water supply system. This project also includes rehabilitating the air conditioning systems, power lines and electrical distribution systems, storm drainage system, and buildings/structures, the majority of which were constructed 30 years ago.

3. Tracking and Data Acquisition Stations 1,700,000

a. Modification of Sixty-Four Meter Antenna, Goldstone, California (400,000)

This project will provide for the rehabilitation and modification of the high pressure hydraulic pumping system for the azimuth hydrostatic bearing assembly at Goldstone. The modified pumping system demonstrated on the antennas at Spain and Australia

increased the thickness of the oil film in the hydrostatic bearing by increasing the high pressure pump flow and permitted the use of higher viscosity oil. Included is an emergency shutdown system with interlocks to prevent bearing damage. The existing system has been in operation since December 1964.

b. Rehabilitation and Modification of Goldstone, California, Electronic Grounding and Testing Systems ($200,000)

This project will provide for the modification and upgrade of the grounding system to reduce or eliminate ground loop circulating currents which interfere with the operation of the electronic equipment. In addition, the load distribution system and transformer bank will be modified and incremental reactive loads will be added to permit performance testing without interference to station operations and mission support.

c. Rehabilitation and Modification of the Electrical System (Power Distribution and Ground Fault Protection)

This project will provide modification and replacement of existing switchgear, increase transformer capacity and underground distribution cable capacity, rehabilitate the ground fault protection and modify the engine-generator control switchgear. In particular, emphasis will be placed on replacing circuit breakers of insufficient interrupting capacity, adding ground fault protection equipment and increasing cable capacity to minimize electrical fires which would shutdown a facility for as much as two months.

Goldstone, California	(DSN)	(495,000)
Canberra, Australia	(STDN)	(160,000)

d. Rehabilitation and Modification of Air Conditioning Systems

This project will modify and refurbish the air conditioning systems in existing operation building which furnish cooling for mission critical electronic equipment. Since the installation of the original equipment, new electronic systems have been added without corresponding increase in the cooling system. In addition, most new electronic systems introduced as replacements of old systems have much greater heat loads. This project will replace worn out equipment such as condensers, fans and motors many of which are 15 years old. Ducting and controls will also be modified or replaced and zones will be re-routed to accomplish optimum heat balance to protect electronic equipment from over heating and to establish a controlled environment for stable electronic operation.

Canberra, Australia	(STDN)	(220,000)
Madrid, Spain	(DSN)	(225,000)

MISCELLANEOUS PROJECTS LESS THAN $100,000 EACH	$1,540,000
TOTAL	$16,000,000

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

It is estimated that between $15 and $20 million per year will be required for the continuation of this facility rehabilitation and modification program.

CONSTRUCTION OF FACILITIES

July 1, 1976 - September 30, 1976

ESTIMATES

PROJECT TITLE	Rehabilitation and Modification of Facilities Not in Excess of $500,000 Per Project	
LOCATION	Various Locations	
July 1, 1976 - September 30, 1976		CoF Estimate $8,750,000
FY 1975 $14,900,000		FY 1976 $16,000,000

COGNIZANT INSTALLATION: Various Locations

LOCATION OF PROJECT: Various Locations

COGNIZANT PROGRAM OFFICE: Office of the NASA Comptroller

SUMMARY PURPOSE AND SCOPE:

This program is intended 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 July 1, 1976 - September 30, 1976 rehabilitation and modification facility needs which can be foreseen at the time of the submission of these estimates, and which are estimated to cost not in excess of $500,000. The purpose of this program is to protect, preserve, and enhance the capabilities and usefulness of existing NASA facilities, and to insure the continued safe, economical, and efficient use of these physical plants.

PROJECT JUSTIFICATION:

At its initial cost, the existing NASA physical plant totals about $5.9 billion (June 30, 1974). A continuing program of rehabilitation and modification of these facilities is required to:

a. Protect the capital value represented by those facilities and to overcome the cumulative effects of wear and deterioration.

b. Insure 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 to overcome the aggregate effects of obsolescence.

d. Provide a better and safer environment for all personnel.

e. Prepare for more efficient energy utilization by updating and improving utility systems.

This project includes only facility rehabilitation and modification 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 which are provided for in other than CoF estimates. Rehabilitation and modification work estimated to cost more than $500,000 is reflected as major CoF line item projects. Not included in this project are the minor construction of facilities projects (new and addition type) required at this time. These latter requirements, for this period, are provided for under a separate project entitled "Minor Construction" which is included in the estimate.

PROJECT DESCRIPTION:

Items of rehabilitation and modification proposed to be accomplished within this program for July 1, 1976 - September 30, 1976 are outlined under "PROJECT COST ESTIMATE" and total $8,750,000. Of this total, $6,000,000 represents discrete work packages all of which reflect requirements at designated NASA field installations which were not included in prior year budget estimates. An additional amount of $1,800,000 is included for the accomplishment of projects which had previously been scheduled in prior year budget estimates but which could not then be undertaken due to the need to revise the listing of work to be accomplished within the allocated resources for a given fiscal year. These revisions are in keeping with the basic intent of this program and have allowed for the accommodation of several urgent but unforeseen institutional projects and many pressing unforeseen program support type facility needs which could not fully qualify for accomplishment under Section 1(g) as "unforeseen programmatic needs". The project also provides $950,000 for those smaller rehabilitation and modification work packages estimated to cost less than $100,000, the nature and purpose of which are the same as for that work specifically delineated but which, because of their individual smaller size, are not listed by item.

They have been carefully selected from lists which originally totalled some $29 million. The $8,750,000 request for this interim period 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. This remainder of the rehabilitation and modification work should be undertaken as a phased program over the next several years to place these installations on a more economical and efficient operating base. 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 this quarter some rearrangement of priorities may be necessary and 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 $6,000,000 of discrete projects relates to the following broad categories of facilities:

a.	Utility Systems	$1,155,000
b.	General Purpose Buildings	1,585,000
c.	Technical Building/Structures	2,395,000
d.	Pavements and Drainage	250,000
e.	Building Exteriors and Roofs	615,000

The request for July 1, 1976 to September 30, 1976 for facility rehabilitation and modification work, therefore, is directed toward the most urgent current needs for work of this type in the continuation of this essential program at the NASA Installations.

Rehabilitation and Modification
July 1, 1976 - September 30, 1976

PROJECT COST ESTIMATE:

A. Ames Research Center $600,000

1. Rehabilitation and Modification of Second Floor of Technical Services Building, N-220 185,000

This project provides for the modification of approximately 10,000 sq. ft. (900 sq. m) of the second floor space of the machine shop facility so that it can be occupied by the instrument maintenance and modification group of the Model and Instrument Machining Branch. The modifications will involve the installation of new light fixtures, redistribution of utilities, floor covering, and air conditioning of some areas to provide a semi-clean-room environment for this group of precision instrument makers. The machine shop building was originally constructed in 1960 and does not have the capability for high precision machinery or instrument repair work.

2. Rehabilitation and Modification of Technical Conference Building, N-201 415,000

This project provides for the rehabilitation of a 30-year old auditorium to incorporate current safety requirements and provisions for the handicapped. This will include adequate access, emergency exits and rest rooms for handicapped personnel who require wheel chairs. The technical briefing and conference area will be modified by installing a stepped floor and fixed seating for approximately 370 people. The lobby, rest rooms, mechanical and electrical equipment will be modified. The rehabilitation work will include acoustical treatment of the auditorium walls, ceiling and floor, and the replacement of the existing windows with brick panels. The existing auditorium was completed in 1944 and requires rehabilitation. There is no existing ramp access for wheel chairs and the emergency exits are inadequate. The present folding chairs are inadequate and could impair escape paths in the event of fire or other emergencies. Rehabilitation is long overdue and the proposed modifications are required to provide an acceptable meeting place for technical conferences.

B. Goddard Space Flight Center 660,000

1. Rehabilitation of Utility Systems 360,000

This project provides for: (1) rehabilitation of steam and condensate lines and associated insulated conduit south of roads 4 and 8, (2) replacing of damaged sections with new casing and providing cathodic protection, (3) rehabilitation of chilled water piping in the same area as well as building connections and internal piping, and (4) sectionalizing

51-423 O - 75 - 38

valves and connections as required. The work will also include other utility modifications within various buildings as required. Examination of portions of these services indicated that subsequent construction had damaged protective coverings allowing steel conduit to corrode. New valving and connections are required to allow necessary sectionalization of external and internal utility distribution systems for maintenance and operational control.

2. Modification of Power Distribution System for the Goddard Optical Research Facility. (Various Buildings and including the Antenna Test Range) $300,000

This project provides for the extension of an existing 13 Kilovolt electric feeder at the main Center to the remotely located Goddard Optical Research Facility (GORF) and the Antenna Test Range. This project includes installation of approximately 12,000 feet (3,600 meters) of electric cable, twenty transformers, and an electrical distribution system at the GORF. This modification work is necessary since the electrical supply to GORF is becoming critical due to the increased number of programs requiring satellite tracking and laser ranging equipment. The programs requiring this equipment are those such as: San Andreas Fault Experiment, EOPAD and GEOS-C. The power to GORF is currently supplied from the Agriculture Research Center's (ARC) 4,160 Volt Distribution System. This power supply has not been reliable in the past because power for GORF has been cut off during electrical emergencies at ARC.

C. Jet Propulsion Laboratory 800,000

1. Rehabilitation of Heating, Ventilating, and Air Conditioning Systems in the Laboratory, Building 161 330,000

This project provides for the rehabilitation of major mechanical components of the heating, ventilating and air conditioning system of Building 161, including overhaul of two centrifugal chillers and installation of a third; replacement of two hot water and two chilled water boilers; replacement of the temperature control system, ductwork extensions/modifications, and diffuser relocations. Reinsulation of work areas, replacement of pneumatic actuator seals and boots, architectural repairs, painting, and complete air balance is included. Clean room and computer installations in Building 161 will be provided with improved redundancy. All existing heating, ventilating and air conditioning equipment in Building 161 was originally installed in 1956 and has been operating continually. Chillers need general overhaul, and redundancy is required for the clean room and computer areas. The main hot and chilled water coils have numerous tubes plugged because of leaks. The cast iron sectional boiler has had three expensive breakdowns and must be replaced by a single fire tube type unit. The control system will be expanded and obsolete equipment replaced.

2. Rehabilitation of Central Recording Center/ Data Acquisition Facility, Building 22, ETS $470,000

This project provides for the modification of Building 22 at the Edwards Test Station and rehabilitation of the overall Central Recording Center System. The work includes rehabilitation of air conditioning system, modification to the interior configuration of the facility, and its systems and interconnecting utilities to the test areas. This project is required to maintain a reliable test center for the ETS in support of the Mars, Jupiter, Saturn (MJS) Program. Present components of the Central System are approximately 12 years old. The building air conditioning is also old and beyond economical maintenance.

D. Johnson Space Center 300,000

1. Rehabilitation of Heating and Cooling Systems, Various Buildings 195,000

This project provides for replacing deteriorated heating and cooling valves, flexible hoses, and several heating and cooling coils. It is required to maintain overall reliability of the heating and cooling systems and to permit more efficient operation of the utility distribution systems within the buildings that were built in the 1964 to 1965 time frame. The valves, expansion joints, pressure-reducing stations, and hoses are approaching the end of a useful life based on like equipment failure and normal life expectancy. This specific effort is part of a continuing program to rehabilitate the most urgent and pressing portions of these heating and cooling systems.

This is part of a phased program to rehabilitate the heating and cooling systems and utility distribution systems. There have been several failures in the steam systems valves and expansion joints. Rehabilitation of the various components is necessary at this time to prevent further deterioration, which could necessitate complete replacement. A major failure within these components could create a definite hazard to operations and could possibly even result in a delay in mission-essential testing.

2. Rehabilitation of Chilled Water Valves, Utility Tunnel 105,000

This project will provide for the rehabilitation or replacement of some 40 worn and/or inoperative valves in the chilled water distribution system in the utility tunnel. These valves are approximately 10 years old and are in need of refurbishment or replacement. At present, inoperative valves involve a shutdown of a building or zones on a more excessive basis then would ordinarily be necessary to

repair inoperative elements. Such shutdowns could cause unnecessary delays in testing due to the lack of a chilled water supply. This is phase four of a 5-year program to replace or rehabilitate the chilled water valves.

E. Kennedy Space Center $430,000

1. Rehabilitation of Roof, Vehicle Assembly Building "Low Bay", Launch Complex 39 290,000

This project provides for replacing 5,000 square feet (460m^2) of water-damaged roof and deteriorated flashing, installing a roof vent to dry out trapped moisture, and 15 roof drains to eliminate water ponding on the roof of the Vehicle Assembly Building (VAB) low bay. This project provides the minimum amount of work to prevent further roof deterioration, in the future, however, it will be necessary to hot-mop and gravel the entire roof area of the VAB low bay.

2. Modification of Vehicle Assembly Building "Low Bay" for Shops 140,000

This project provides for modifying the existing shop and test areas in the Vehicle Assembly Building (VAB) low bay to provide permanent facilities for the electronic/electric, fabrication, pneumatic/hydraulic, and wire rope shops. It will centralize widely scattered facilities and provide for more efficient operation. Work includes removing existing partitions; installing waste and exhaust, hot and cold water, and compressed air systems; improving ventilation; and adding power outlets and lighting.

F. Langley Research Center 770,000

1. Rehabilitation of Hypersonic Propulsion and High Intensity Noise Facility, Building 1221 280,000

This project will rehabilitate 58,000 sq. ft. (5,400 m^2) of office, shop and laboratory spaces on the first and second floors of Building 1221. Noise research valving and control rooms will be modified to effect a savings in research time and money. Automatic valve controls and control room modifications will permit two aircraft noise facilities (Building 1221 and Building 1218) to conduct research simultaneously rather than the present arrangement which permits only one facility to operate with the other waiting. The research conducted here complements the research at the other facilities; it does not duplicate the research effort. Since both facilities are now operated separately, this will result in a savings in both time and research effort. The work will include repair of the exterior masonry walls, replacement of wooden windows, roof repair, improvement of rest rooms,

HVAC system modernization, fire protection system installation, and refurbishment of doors and interior finishes. This facility was constructed in 1946. The extensive research performed in the building and the general deterioration that has occurred now necessitates a general rehabilitation. The walls, roof, and windows have exhibited deterioration. Automatic control of air valves and control room improvements are needed. Building 1221 is used exclusively for structural-acoustical (sonic fatigue) research and the flow field-near field jet noise research in the static condition.

2. Rehabilitation of Technical Conference Facility, Building 1222 $240,000

This project consists of the rehabilitation of Langley's Technical Conference Facility which is required to adequately serve the Center's main conference needs. This includes modifying the existing presentation facilities and relocating the projection room to more effectively utilize the conference area. Also included in this rehabilitation are provisions for adequate fire protection devices, repairs to interior and exterior walls, replacement of deteriorated windows and doors, upgrading rest room facilities, and improvements to the existing air conditioning and utility system. The present facility was constructed in 1946 as a combination recreation/conference area, and is completely unsuited for the conference activities which is now serves. For example, there are approximately eight meetings per month, each with an average attendance of 200 people. Attendance often exceeds 400. Expansion of the projection room is required to adequately accommodate the equipment necessary for a technical presentation. A 90-degree rotation of the speaker's area and the projection is necessary to effectively utilize existing space. The existing building systems and finishes are substandard and deteriorated to the point of requiring excessive maintenance.

3. Rehabilitation and Modification of West Area Main Road System 250,000

In conjunction with the new development and continued growth in the West Area of LaRC, the increased vehicular flow through the Center requires that the traffic patterns be developed along certain main streets. This project will provide for a continuation of Walcott Road to Ames Road and the rehabilitation of a portion of Ames and Durand Roads, the intersection of Ames Road and Durand Road, and traffic control improvement throughout the area. The work will include some demolition, paving, drainage, and road repair or resurfacing. The traffic composition in the area of the main gate is primarily a result of several small streets all intersecting in a small area. No main thoroughfare exists which can channel the traffic to the heart of the Center. Also, the ever increasing

traffic flow of trucks to the warehouse area, cars to the East Area, and visitors to the Visitor Center necessitates a main thoroughfare to these areas. This project will provide the necessary continuity of the entrance road system and will materially aid the flow of traffic into the Center.

G. Lewis Research Center $600,000

1. Rehabilitation of the Instrument Research Laboratory, Building No. 77 490,000

This project provides for the rehabilitation of approximately 37,400 sq. ft. (3,470 m^2) of the Instrument Research Laboratory, Building No. 77. The exterior rehabilitation includes tuck pointing, cleaning and waterproofing the masonry work, caulking all stone joints and the installation of new aluminum windows. The interior rehabilitation will include some new flooring, ceiling, and lighting. The electrical system will be upgraded where required. The heating, ventilating, and air conditioning equipment will be replaced and the rest rooms renovated. This building was constructed over twenty years ago and has received only routine maintenance. The extensive rehabilitation of the interior and exterior features of the structure are required to bring it up to current standards.

2. Rehabilitate Air Dryer for the 8 x 6 Supersonic Wind Tunnel, Building 57 110,000

This project will provide for the rehabilitation by replacement of the elements in the Air Dryer for the 8 x 6 Supersonic Wind Tunnel. The deterioration of these elements after 24 years of continuous use has resulted in poor performance of the air dryer and has now reached a point where positive corrective action must be undertaken. Rehabilitation of these working parts of the air dryer will increase its moisture absorption capability and reduce the amount of natural gas and electric power required for this operation. This work will further reduce the amount of maintenance needed on this system.

H. Marshall Space Flight Center 470,000

1. Rehabilitation of Guidance and Control Building, Building 4487 470,000

This project consists of general rehabilitation of the western portion of the "A-wing" and the entire "AB-wing" in Building 4487. Work includes removal of various obsolete and

overloaded air conditioning units, air handlers, and chillers; installation of an adequate centralized air conditioning system; and connection of the air conditioning system to an existing central chiller. Power distribution and lighting systems will be replaced and damaged architectural surfaces, window screens, and doors will be repaired or replaced. The exterior will be repainted. This rehabilitation will result in energy conservation and reduce maintenance costs. It will also facilitate the consolidation of various electronic and control activities from other buildings into Building 4487. This project comprises the second phase of the five-year plan begun in FY 1975 for the general rehabilitation and upgrading of Building 4487 to meet operational requirements imposed by current R&D usage.

I. Michoud Assembly Facility $225,000

1. Rehabilitation of Roofs, Engineering Buildings 101 and 102 225,000

This project provides for removing and replacing the entire 41,854 sq. ft. (3,851 m^2) built-up roof on Building 101 and the entire 57,275 sq. ft (5,269 m^2) built-up roof on Building 102. These roofs were built in 1943 and rehabilitated in late 1961. Despite patches and repairs, the roofs on these buildings still have numerous leaks, soft spots where insulation has been saturated, and blisters from trapped moisture. To correct these problems and to preserve the wooden building roof structures, these roofs must be replaced now.

J. National Space Technology Laboratories 210,000

1. Modifications to Maintenance Buildings, Buildings 2201 and 2205 210,000

This project provides for modifying the Maintenance Buildings 2201 and 2205 to comply with safety standards. Modifications to Building 2201 include installing a dust collector system in the carpenter shop; installing a vehicle exhaust system; vaporproofing the electrical conduit system in the automotive area to prevent explosions; providing a ventilated, enclosed area for the battery shop and storage; and providing an enclosed paint spray booth. Building 2205 modifications include providing a fume exhaust system in the cleaning tank area, rehabilitating the chiller absorption unit and pumps, replacing mercury lamp ballasts, and repainting exposed structural steel in the cleaning tank area.

K. Wallops Flight Center $200,000

1. Rehabilitation of Two Buildings; Assembly Shop, Building W-15, and Gymnasium and Post Office, Building D-10 100,000

This project provides for the rehabilitation of the following two buildings:

a. Building W-15: This work includes floor repair and installation of vinyl asbestos tile flooring in the stock room, installing of an exhaust system in welding area, air conditioning in shop area, replacing incandescent lighting with fluorescent lighting, install eyewash fountain in the battery preparation area, weather stripping all exterior doors, replacing steam boilers with new unit, sealing around metal siding and behind interior and exterior of building, construction of a sidewalk behind the storage building and replacement of underground communications service cable.

b. Building D-10: This work includes replacing door sills and doors, patching floors, rehabilitating rest rooms, ceiling/wall areas, heating, ventilating and air conditioning systems, and lighting system. Calking and sealing all building windows and painting interior office areas.

The work to be done in the above buildings is urgently required to prevent further deterioration and to provide a suitable working environment.

2. Modification of Water Distribution System 100,000

This project provides for modification of the existing water system by constructing some 2,800 linear feet (853 meters) of 10-inch water line including related fittings and valves. This line will be connected to an existing 8-inch (20.32cm) water line approximately 350 feet (106.75 meters) southwest of the Bulk Materials Storage Building N-116, then in a southwesterly direction crossing the paved apron east of the Range Control and Evaluation Facility, Building N-159, continuing southwest outside the edge of a wooded area past Building N-161 to a point approximately 150 feet (45.75 meters) east of the Telemetry Control Building, N-162, then running northwest along the north side of N-162 and connecting to an existing ten inch line at Building N-162. Two more connections will be made along the proposed line to connect an existing stubbed out line northeast of Building N-159 and an existing line northeast of Building N-161. This modification to the water system is needed to connect the existing dead end water line back into the water system by means of looping. This loop will give the two

following improvements: (1) circulation through the lines needed to maintain adequate pressure during fire use, and (2) a higher quality to the water used in human consumption. The size of the proposed line will be adequate to accommodate possible future expansion to the service area.

L. Various Locations $2,535,000

1. Rehabilitate Roof, Space Systems Development Laboratory, Building 288, Downey, California 100,000

This project provides for removing the entire roof of Building 288 and replacing it with a new built-up roof. All roof penetrations will be provided with new flashings, and vents will be installed to prevent the formation of blisters. The present roof was installed when the building was constructed in 1964 and has deteriorated to the point that only complete replacement can restore the integrity of the roof and prevent damage to the building and its contents.

2. Rehabilitation and Modification of Various Buildings, White Sands Test Facility 240,000

This project provides for refurbishing and improving eight buildings in the "100 and 200 areas" representing approximately 137,000 square feet (12,732 m^2) of floor area. The modifications include replacing corroded water lines, installing fire protection and safety appurtenances, replacing inefficient air conditioning equipment, and installing new floor tile and ceiling panels. The work also includes rehabilitating an air distribution system, weather stripping various exterior doors, replacing an interior door, painting part of the interior, installing an overhead vehicle exhaust system in one building, constructing a blast wall in one building, and installing a sawdust collection system. The rehabilitation and modifications are necessary to reduce maintenance costs by conserving energy, and to comply with current standards.

3. Tracking and Data Acquisition Stations 395,000

a. Rehabilitation and Modification of Electrical System (cabling and ground fault protection), Goldstone, California (DSN) (290,000)

This project will provide modification and replacement of the existing 5,000-volt and 600-volt cabling and ground fault protection for the 480-volt systems. In particular, it will provide protection from catastrophic arcing grounds in the 480-volt system; replace the existing nonshielded cable with shielded cable and place the 2,400- and 600-volt cables in separate raceways to conform to changes to the State of California basic electrical regulations.

b. Modification of Sixty-Four Meter Equipment Room, DSS-14 ($105,000)

This project will provide for a modification to the back-up structure of the prime reflector to install electrical equipment at a minimum distance from the tricone. Overcrowded electronics in the tricone will be relocated thereby increasing the width of the access walkways within the tricone to conform to the State of California basic electrical regulations.

4. To provide for the accomplishment of project work which had previously been scheduled but which could not then be undertaken due to the need to revise the listing of work in favor of more pressing institutional and program support work to be accomplished within the allocated resources for a given fiscal year. 1,800,000

a. Modification to Arc Heater and Test Bay of the Mach 50 Helium Tunnel Building N-238, Ames Research Center (340,000)

An existing electric arc air heater will be modified and reinstalled in the test bay of Building N-238. New water manifolds, four inch gas line, electric controls, switch gear, and cables will be provided by this project.

This modification work will provide a capability to perform tests to determine the effects of massive boundary layer transition and turbulent heating rates at high stagnation pressures. The information obtained from these tests will be used in the design of thermal protection systems (TPS) for ballistic missiles and for planetary probes. The unique capability of this arc will be the proper scaling of model and gap size in relation to boundary layer thickness. A large arc heater such as the one proposed will permit precise determination of heat shield performance under turbulent boundary layers. This will result in a significant increase in the payload of entry vehicles. The power supply (60 megawatts) provided for the Interaction Heating Shuttle Test Facility under a FY 1972 CoF project will also be used to power this arc heater. The resultant combustor will greatly enhance the capabilities indicated.

Although this modification work will provide a completely operational facility in itself, it may be necessary to undertake additional modification work at a later time in this facility to achieve greater capabilities. This proposed new requirement is being fully evaluated and would cost approximately $450,000. This proposed future work will be a separate and distinct project from that described above and, if later approved, will be funded as a separate project.

b. Rehabilitation and Modification of the Heating, Ventilating and Air Conditioning System in Nine Laboratory Buildings, Goddard Space Flight Center (175,000)

This project provides for the rehabilitation and upgrading of the heating, ventilating and air conditioning system in Buildings 1, 4, 11, 14, 18, 19, 20, 21 and 25. It includes: upgrading the air conditioning on the south side of Building 1 to relieve solar heat gain and to provide zone and cycle control, upgrading the air conditioning system of the laboratory in Building 4; providing a ventilation system and insulated wall in the steam station, Building 11; installing a ten ton air conditioning unit for the first floor of Building 14; rehabilitating the entire system in Buildings 18, 19 and 20; upgrading the system on the south side of Building 21; and increasing the air quantities and provide additional humidification in the computer areas of Building 25. These modifications are necessary to meet the changed occupant requirements of the buildings as well as the rehabilitation of deteriorated equipment involved.

c. Modifications to Mission Support Area, Space Flight Operations Facility, Building 230, Jet Propulsion Laboratory (300,000)

This project will modify the computer area of the Space Flight Operations Facility (SFOF), rehabilitate the cabling and ground system, and separate the mission control and computing center communications functions from those of the Deep Space Network. This project provides for extensive modifications to the SFOF to satisfy project requirements. It is also necessary to upgrade the ground system to reduce noise levels, and improve equipment operations and communications between SFOF and the Systems Development Laboratory, and to rearrange the communication equipment. Work of this nature is a continuing requirement in light of mission operations utilization of this facility.

d. Rehabilitation of Anechoic Chamber Doors, Building 14, Johnson Space Center (75,000)

This project provides for the repair of Anechoic Chamber doors to Building 14. The doors were installed in 1964 and at present require installation of new "fingerstock" (an interlocking radio frequency shield) on the large chamber door and cleaning the contact surface of the minor fingerstock, installation of new weatherseals and refurbishment of the interlock switches and air cylinders. A study was made to determine the amount of damage

and deterioration of the doors, and it concluded that the continued rate of deterioration, if not corrected, may seriously impact the shuttle and other testing to be performed in the chamber. Penetration of moisture and dirt through improperly closed and weather-sealed doors will cause deterioration of the radio frequency (RF) absorber material, which would be extremely costly to repair. This project is required in order to maintain integrity in the results of electromagnetic interference (EMI) tests.

e. Rehabilitation of Aircraft Parking Apron, Langley Research Center ($250,000)

This project provides for the rehabilitation of the existing aircraft parking apron with construction of a 3,800 square yards (3,177.7 m^2) concrete extension. This extension will be located on the south side of Building 1244, near the end of the main taxiway going to the Air Force main runway. The new apron extension will improve flight operations at Langley by providing a better flow of traffic from the taxiway and improve operations in parking and maneuvering aircraft and equipment. For some time, operations have been impeded by restricted ramp space. Traffic includes such large aircraft as the C-310, C-54, G-159 and CH-54 (Flying Crane Helicopter) in addition to numerous smaller jet, reciprocating engine, and rotary wing aircraft. Other large transient aircraft (C-141) often utilize the NASA ramp. Twenty aircraft are now assigned to this Center including the Boeing 737. Inefficiency in ground handling operations involves not just loss of time, but also unnecessary manpower. This project will also involve removal of the existing fueling system which will be replaced by truck fueling. The replacement of the fueling system is necessary since the existing one is obsolete and does not have sufficient pressure or volume to accommodate present and future aircraft requirements.

f. Rehabilitate Electrical Power Distribution System, Lewis Research Center (200,000)

This project provides for the rehabilitation of several components of the electrical power distribution system. The undersized 2,400 volt tie cable between transformers "B2" and "G4" is inadequate to handle essential loads in the event "B2" is required to be removed from service. Transformer "B2" provides electrical power for critical loads throughout the Center. This project also

provides for the replacement of the high voltage 34.5 KV "potheads" at Substations "A" and "B". These original dry-type high voltage potheads were installed 30 years ago, some have failed and all need replacement. The adjacent potheads when dismantled have indicated evidence of imminent failure. This project also includes the replacement of the control cables from the Electrical Distribution Center to Substation "B", the Sewage Pumping Station No. 1, Building No. 26, to the switching apparatus at Substation "C", and from Manhole 38 to Manhole 7. All of these cables indicate considerable sign of deterioration also, resulting in a condition of imminent failure. Additional rehabilitation of the Center's electrical power distribution system will be required in future years.

g. Rehabilitation of Guidance and Control, Building 4487 ("A" Wing East), Marshall Space Flight Center ($460,000)

This project provides for rehabilitation of 45,000 square feet, first and second floor, "A" Wing East, Building 4487. The work includes removal of various obsolete and overloaded air conditioning units, air handlers, chillers, and the installation of a centralized air conditioning system connected to an existing new central chiller. Power systems will be replaced to provide required breakers and controls for special loads such as computers. Lighting systems will be modified to meet required illumination levels. In addition, repair or replacement and painting of partitions, doors, windows, and ceilings will also be required. This building was built in 1956 as a Guidance and Control Laboratory for the Army, using austere standards of construction, and has since become inadequate to meet demands and loads of current aerospace research. Wear and tear of the building and its poor utility systems have increased maintenance and has been the cause of having to make piecemeal additions to the systems to meet even the minimal operational requirements of the research activities in the building. Future funding to rehabilitate other wings of the building will be required in the future.

MISCELLANEOUS PROJECTS LESS THAN $100,000 EACH	$950,000
Total	$8,750,000

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

It is estimated that between $15 and $20 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 1976 ESTIMATES

Minor Construction

Summary of Project Amounts by Location FY 1976	Amount	Page No.
Ames Research Center	$535,000	CF 6-2
Flight Research Center	205,000	CF 6-3
Goddard Space Flight Center	235,000	CF 6-4
Jet Propulsion Laboratory	520,000	CF 6-4
Johnson Space Center	50,000	CF 6-5
Langley Research Center	675,000	CF 6-6
Lewis Research Center	185,000	CF 6-7
Wallops Flight Center	145,000	CF 6-8
Various Locations	1,700,000	CF 6-9
Miscellaneous Projects Less than $50,000 Each	750,000	CF 6-10
Total, FY 1976	$5,000,000	

Transition Period
July 1, 1976 - September 30, 1976

Ames Research Center	155,000	CF 6-13
Goddard Space Flight Center	595,000	CF 6-14
Jet Propulsion Laboratory	480,000	CF 6-15
Johnson Space Center	160,000	CF 6-16
Langley Research Center	280,000	CF 6-16
Tracking and Data Stations	330,000	CF 6-17
Various Locations	500,000	CF 6-18
Miscellaneous Projects Less than $50,000 Each	450,000	CF 6-19
Total, Transition Period	$2,950,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

PROJECT TITLE	Minor Construction of New Facilities and Additions to Existing Facilities not in Excess of $250,000 Per Project
LOCATION	Various Locations
	FY 1976 CoF ESTIMATE $5,000,000
FY 1974 $4,600,000	FY 1975 $4,500,000

COGNIZANT INSTALLATION: Various Locations

LOCATION OF PROJECT: Various Locations

COGNIZANT PROGRAM OFFICE: Office of the NASA Comptroller

SUMMARY PURPOSE AND SCOPE:

To provide for minor facility construction at NASA field installations and at Government-owned industrial plants engaged in NASA activities. This provides for minor facility projects involving the construction of new facilities or additions to existing facilities, each project of which is estimated to be not in excess of $250,000. Such minor construction is necessary in FY 1976 to further improve the usefulness of NASA's physical plant by making it possible to accomplish needed adjustments in the utilization and augmentation of its capabilities.

PROJECT JUSTIFICATION:

The existing NASA physical plant is necessarily impacted by changing utilization and adaptions required by changing technology and mission needs, as well as by new facility requirements generated by research, development, test, and like activities. Items included in this project reflect work which must be accomplished in FY 1976 to meet general NASA installation requirements or technical facility needs.

This work is not solely or primarily required to support specific research or development programs. However, included are those items which are required in FY 1976 to meet the particular needs of one or more specific research or development programs and which can be adequately identified at

the time of submission of this budget estimate. Items of work proposed to be accomplished within this program for FY 1976 have been carefully selected from a list totaling about $9 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:

Tentative subprojects of work to be considered for accomplishment under this estimate are outlined under "PROJECT COST ESTIMATE" and total $5,000,000. Of the $5,000,000 total, $4,250,000 represents specific discrete items of work identified in this documentation and the balance, $750,000, is indicated as a "lump sum" amount to provide for facilities work of these types (new construction and additions) at the various field installations and estimated to cost not in excess of $50,000 for each such project. This amount in turn is based on a presentation of specific project tasks of the new construction type which must be accomplished in this time frame.

PROJECT COST ESTIMATE:

A. Ames Research Center $535,000

1. Construction of Flood Control Basin 240,000

This project provides for the construction of a drainage basin of approximately 2 acres (8094 m^2) located within the north boundary of Ames Research Center, approximately 1/2 mile (800m) south of north boundary of the Center. Pumps and a discharge line as well as the necessary electrical utilities are included. This land is below the level of San Francisco Bay due to subsidence; thus, rain water run-off presently stands on Center property until it becomes stagnant, and becomes a breeding ground for mosquitos. The V/STOL static test stand and magnetic test facilities are located adjacent to this flooded area. The project is urgently needed for both health and environmental reasons.

2. Construction of Control Room for Static Test Facility, N-249 170,000

This project provides for the construction of an underground control room, fuel supply, and electrical service for the new static test facility. The work consists of a 30-foot by 40-foot (9m by 12m) concrete control room for personnel protection and security of important instrumentation. Electrical service consisting of 480 and 280/120 volts and relocation of existing floodlights for night operation will also be provided. Because the site is remote from other facilities, fire alarm, telephone service, and sanitary facilities are required for the operating personnel.

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The existing test control and instrument rooms are portable trailers which all provide little protection for operating personnel or research equipment for hazards inherent in developmental research with rotor type aircraft. The trailers, regardless of protection that could be constructed, also present a reflective surface that compromises acoustical measurements associated with this testing. Current emphasis on V/STOL research and especially in the development of more efficient and quiet aircraft, in addition to the hazardous elements of the present arrangement, make it necessary that the proposed improvements be made. The data acquisition system for this static test facility will require some modifications in the future.

3. Addition Within the Flight and Guidance Simulation Laboratory, Building N-243 $125,000

This project will provide an interior addition to Building N-243. There will be four laboratories on the first floor, and an equal area for offices above the laboratories for a total gross area of 5,600 sq. ft. (504 m^2). The laboratory space will provide control and maintenance areas for the visual scene generator and set-up areas for simulation experiments. The building was originally built as a simulation laboratory with office space for approximately 40 people, but it presently is required to house over 100. Simulator control rooms are being occupied as office space by personnel using the Flight Simulator for Advanced Aircraft (FSAA) in support of FAA Certification programs; conference rooms, utility rooms, and laboratory spaces occupied by visiting experimenters using the FSAA in support of Advanced Medium STOL Transport (AMST); Tilt Rotor; Quiet Short Haul Research Aircraft (QSRA); Rotor Systems Research Aircraft (RSRA); and Space Shuttle Orbiter experiments, and by support service personnel for various simulators located in this building.

This project will convert presently uncommitted floor space to relieve this severe congestion which at this time severely hampers full and efficient utilization of the Center's simulation facilities.

B. Flight Research Center $205,000

1. Construction of a Storage Warehouse 205,000

This project provides for the construction of a pre-engineered metal building 80 feet (24.4m) by 120 feet (36.6m) by 24 feet (7.3m) eave height. The structure will provide warehouse space of a gross area of 9,600 square feet (892 m^2). The structure will be provided with minimum utilities consistent with warehouse occupancy. These minimum utilities will include fire protection, lights, 120/208 volt power, natural gas heating, and evaporative cooling.

This project will provide space to meet the increasing requirements for parts storage. As newer aircraft are added to the inventory of the Flight Research Center, particularly those one-of-a-kind aircraft such as the

X-24B, F-111 TACT, Remotely Piloted Research Vehicles and Highly Maneuvering Aircraft Technology (HiMAT), greater storage space is required which does not exist at the present time.

C. Goddard Space Flight Center $235,000

1. Construction of Frequency Standard and Test Building 235,000

This project provides for the construction of a frequency standard and test facility with an area of approximately 1,200 square feet (111 m^2). The exterior walls will be aluminum with cement block liners located on a heavy concrete slab base. The facility will have two screen rooms, a laboratory, and office space with heating and air conditioning. The project also includes 1,000 feet (305m) of fencing with an entrance gate and parking area which is to be located near the gate. The facility will be located 500 feet (150m) from any roads and in a tree area for the radio frequency (RF) shielding. To satisfy the Agency's requirements for precise range data to satellites and Network Very Long Baseline Interferometry (NVLBI) in the 1976-1977 period, timing and frequency control techniques are being developed. To test and maintain these standards, a facility is required that is vibration isolated, thermally controlled and radio frequency quiet. The facility will be used as a basic calibration standard as well as a laboratory in which research and development programs will be conducted.

D. Jet Propulsion Laboratory $520,000

1. Construction of Addition to Building, TM-17, Table Mountain (TM) 235,000

This project proposes the construction of a 3,500-square foot (326 m^2) addition to the existing headquarters building (TM-17) at the Table Mountain facility. Approximately 2,000 sq. ft. (186 m^2) will be added to the south which will provide additional offices, technical equipment storage, facility operational supply storage, and a mechanical room for heating, ventilating, and air conditioning equipment. Approximately 1,500 sq. ft. (140 m^2) will be added to the north for a sleeping area. Construction will be of masonry and heavy duty fireproof roofing shingles to match the existing building. The new facility storage space is the only area on the entire remote site where standard operating supplies, including emergency food supplies, can be kept. The existing headquarters building contains only one office, four bedrooms, and no storage facilities. All scientific and technical personnel are housed in substandard cottages which are over 45 years old and which are extremely expensive to maintain and heat. They are also located sufficiently distant from the headquarters building to make bad weather travel hazardous and inconvenient. Completion of this addition will permit demolition of the last three remaining buildings constructed by Smithsonian personnel (TM-8, TM-10, TM-11).

2. Construction of Control Room, Antenna Laboratory $55,000

This project provides for the construction of a 600-square foot (55.2 m^2) control room for Building 212, west range. Construction will consist of concrete footings and floor slab, masonry block walls, built-up roofing, lighting, air conditioning, five (5) sprinklers, and an evacuation alarm system. The new systems will be extensions of the existing systems in Building 212. The present area used for this control function is approximately 144 square feet (13.25 m^2) located in the north west corner of Building 212. During tests, the access used by personnel is through a window onto a wooden platform and then down some stairs. Due to the ever changing state of the art and the utilization of new equipment in a small area, it has been necessary to stack electronic equipment on top of each other in order to conduct tests. The amount of equipment in this small area has precluded the possibility of having a work bench or desk in the area. Construction of this control room will provide an adequate room for equipment and suitable working area for personnel.

3. Construction of Technical Service Facility at Edward Test Station (ETS) 230,000

This project will provide for the construction of a 2,700-square foot (245 m^2) concrete masonry unit structure. The structure will be air conditioned as required and include High Efficiency Particulate Air Filter (HEPA) for the "clean" area. Standard partitions, drop ceilings, floor tile, and rest rooms will also be included. This building will provide a major increment of a central facility designed to consolidate the major, nonhazardous technical support activities at ETS. These functions include instrumentation repair and calibration, chemical laboratory, transducer calibration and repair and a small clean assembly capability. This facility will be designed to consolidate scattered operations in a single up-to-date laboratory type building. Instrumentation work is currently in 10' x 45' (3.1m x 13.9m) and 8' x 35' (2.4m x 10.7m) standard trailers; the clean laboratory is in a 15-year old deteriorated trailer; the chemical laboratory is in a 29-year old "temporary" stud and stucco, much modified building. Maintenance costs are excessive, some project environmental requirements cannot be met, operation and administration costs are excessive. Hazardous chemicals have to be shipped off ETS for necessary analytical work for lack of capability. This project would accelerate demolition of older buildings and trailers that are no longer economical to maintain and is the key element of work to initiate implementation of the ETS Master Plan.

E. Johnson Space Center $50,000

1. Addition to Pyrotechnics Test Facility, Building 352 50,000

This project will provide additional space in the Pyrotechnics Test Facility, Building 352, to permit total qualification of initiators and flight-type hardware for the space shuttle program because existing space

is insufficient to house all the test equipment required for shuttle qualification testing at any one time. The work includes enclosing the concrete apron area on the east side of the building to make it an integral part of the existing high bay area. The access drive and walkways will be extended to the new door on the east side. The vibrator system cooling tower, exterior lighting, and fire alarm systems will be relocated. The new area will be provided with interior lighting, electrical circuits, and heating and air conditioning ducts.

F. Langley Research Center $675,000

1. Addition to Environmental and Space Science Laboratory, Building 1250 245,000

Office space is required for Environmental and Space Science Division personnel adjacent to the laboratory space they are presently utilizing in Building 1250. This project will provide a 5,000-sq. ft. (465 m^2) gross floor area office addition on the west end of the building. The addition will be constructed with a reinforced concrete foundation and floor slabs, a structural steel frame, and brick veneer cavity walls with insulated metal panel window units. All necessary heating, ventilating, air conditioning, lighting, and electrical power distribution will also be provided. Seventeen people will be moving into the new addition from trailers, with six of these also vacating laboratory space in Building 1293B. Twenty-five people will be moving from laboratory space in Building 1250 to the new addition. Because of its unique chemistry and biology laboratory accommodations, Building 1250 provides the logical facility for the consolidation of the environmental quality research and the high bay area provides excellent space for advanced technology laboratory development activity. At the present time there are 105 people occupying the building. Since the building was designed with office space for only 60 people, many of the occupants are using laboratory areas for offices, and there is severe crowding in the existing office space (less than 90 sq. ft./individual). The Langley environmental quality program has reached the point where the laboratory area used as office space is badly needed for research. This laboratory space is expensive and it is cost effective to construct the proposed office addition to Building 1250 to capitalize on existing laboratory areas and to alleviate overcrowding.

2. Construction of Administrative Management Building 240,000

Space is required on the West Area for records and personnel from the Personnel Division which are now located in the East Area. This project consists of a new masonry structure of approximately 5,000 square feet, (465 m^2) gross area. It will be located on the southwest corner of the intersection of Ames Road and Moffett Road and will house approximately 40 people. The building will initially be provided with corridors, rest rooms, and mechanical equipment room, with the remaining areas left open to provide maximum flexibility. Eighty-five percent of the Center's workforce is located in the West Area while the bulk of personnel division staff is in

the East Area. The distance of four miles, each way, to conduct personal transactions is both costly and inefficient while at the same time inhibiting the total involvement of the personnel staff in providing consultation and advice, due to their physical location. Another costly trade off pivots around the integration of the resources management systems involving payroll, business data systems division, and the personnel records unit. Centralization of personnel members will greatly reduce the built-in "time lag" for the numerous daily interfaces now encountered under the present East Area-West Area splintering.

3. Addition for Training Facility, Building 1194 $190,000

This project provides for an addition to the existing Library, B-1194, to be used for training in the West Area at LaRC. The addition will have approximately 4,000 sq. ft. (372 m^2) of classroom and administrative space, including necessary rest rooms and hallways. The Center's broad gauged training programs critically need additional space. These programs include apprentice training, equal employment training, secretarial, and upward mobility programs; and renewed emphasis upon short courses and specialized seminars to be offered locally. The present use of trailers as an interim measure is only a temporary solution because the space utilized is inadequate, has limited life and higher maintenance costs. Training is receiving increasing attention and this addition is vitally needed to meet identified needs. Phasing out classroom space in the East Area will curtail the need for several hundred trips per week with the attendant lost time involved.

G. Lewis Research Center $185,000

1. Shop Addition to 8 x 6 - Foot Supersonic Wind Tunnel, Building No. 55 80,000

This project will provide for a new shop building 63' x 30' x 22' high (19.2m x 9.1m x 6.7m) to be constructed adjacent to Building 55, 8 x 6 Supersonic Wind Tunnel (SWT) and Building 56, the Structural Dynamics Laboratory. The walls of the adjacent buildings will be used for two sides and the other sides will be constructed of concrete block. The roof will be steel joist, metal deck and built-up roofing. Electrical service, lighting, heating and other services will be provided. The shop will have a monorail and hoist with large roll-up door. The floor will be a concrete slab on grade.

Over the years the Spacecraft Preparation Area and Environmental Test Area has slowly expanded to a point where the 8 x 6 SWT support group no longer has a suitable work area in which to perform their duties.

The proposed new addition of 1890 sq. ft. (175.6m^2) will provide enough additional space to permit rearrangement of present facilities in a manner that will provide suitable area for the 8 x 6 SWT service support group.

2. Addition to Engine Research Building (ERB) No. 5 (Office Section) $105,000

This project will provide a needed second floor safety exit for the personnel in the ERB office section. Presently the personnel have access to only one exit which does not meet the safety standards. The addition will be a matching brick structure, two floors in height, with built-up roof and relocated matching aluminum sash. It will include heating, air conditioning and electrical work. The new stairway will have metal fire doors top and bottom. Design of the structure and site changes will blend with present surroundings and be esthetically pleasing.

At the present time, two means of egress from the second floor office section of ERB No. 5 which meet code and safety requirements do not exist. The proposed addition would incorporate an acceptable second means of egress. In addition, a much safer and accessible entrance and exit would be provided on the first floor for stretcher patients of the Medical Service Unit.

H. Wallops Flight Center $145,000

1. Construction of Addition to Airfield Radar Control Building, A-41 145,000

This project provides for an 1,800-square foot (167 m^2) addition to the West side of existing Building A-41. This will include rest room facilities, storage area, office and shop areas. This addition is to be constructed of masonry walls over concrete foundation and reinforced concrete floor slab. The roof structure shall be shed type and attached to the existing roof framing on Building A-41. The new area shall have a suspended acoustical ceiling, electrical power, lighting, heating, ventilation and air conditioning. A septic tank and drain field system, new well system and extended bituminous parking area will also be provided. Since the installation of the basic radar system equipment, other associated equipment has been added. All of this equipment has been concentrated in order to minimize impacting the office and shop areas. This has created operational problems, especially with the number of people in this one large room. It is now planned to add eight more racks of project support equipment which will require using the present office and shop areas. This will make necessary the additions provided by this project.

I. Various Locations $1,700,000

1. Construction of Support Facilities for Mobile Lasers (LAGEOS) at Various Locations 1,310,000

This project will provide for the construction of support facilities for the periodic locations of seven mobile, precise laser tracking stations to support the Laser Geodynamic Satellite (LAGEOS). This project is designed to define the global tectonic plates, plate motion (earthquakes), plate stress and information about fault structures. The construction will consist of site clearing, grading, road construction, erection of temporary shelters, trailer hardstands, boresight towers, wind holddowns, groundings and sanitary facilities. Higher costs are estimated at the remote sites due to their distances from supporting centers and area locations. All costs have been tailored to the proposed sites.

The estimated cost to construct these facilities at these locations ranges from $100,000 to $235,000.

Each of the seven sites will be managed as a separate project because of the different locations envolved. This is the second increment of these LAGEOS projects. The first encrement was funded in FY 1975 at $980,000. The subsequent third increment will be approximately $750,000.

2. Installation of Commercial Power Service to Rosman (STDN) Station 240,000

This project provides for the installation of a commercial power service to the Rosman STDN station. The system will provide overhead cable service to within 2,000 feet (610m) of the site, direct burial cable installation from this point to the power plant and suitable outdoor switchgear and transformers to apply the service to the site load via the existing distribution system. This project will increase the reliability of station power by providing two independent sources and also will reduce operating costs.

3. Construction and Additions to Facilities at Industrial Plants 150,000

This project provides for the minor facility construction needs as required at the Government-owned industrial plants engaged in NASA activities. This work which is not directly program related involves the necessary erection of buildings and structures, installation of equipment, assembly of a new facility, a replacement facility, or the addition to an existing facility associated with the NASA industrial plants. This project is to provide for the priority work of this nature which will arise but cannot be specifically identified at this time. The work to be included in this project must be accomplished during this time in order to meet general NASA requirements at these industrial plants.

MISCELLANEOUS PROJECTS LESS THAN $50,000 EACH	$750,000
TOTAL	$5,000,000

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

It is estimated that between $4 and $6 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.

CONSTRUCTION OF FACILITIES

July 1, 1976 - September 30, 1976 Estimates

PROJECT TITLE	Minor Construction of New Facilities and Additions to Existing Facilities Not in Excess of $250,000 Per Project	
LOCATION	Various Locations	
July 1, 1976 - September 30, 1976	CoF ESTIMATE $2,950,000	
FY 1975 $4,500,000		FY 1976 $5,000,000

COGNIZANT INSTALLATION: Various Locations

LOCATION OF PROJECT: Various Locations

COGNIZANT PROGRAM OFFICE: Office of the NASA Comptroller

SUMMARY PURPOSE AND SCOPE:

To provide for minor facility construction at NASA field installations and at Government-owned industrial plants engaged in NASA activities. This provides for minor projects involving the construction of new facilities or additions to existing facilities, each project of which is estimated to be not in excess of $250,000. Such minor construction is necessary during the period July 1, 1976 to September 30, 1976 to further improve the usefulness of NASA's physical plant by making it possible to accomplish needed adjustments in the utilization and augmentation of its capabilities.

PROJECT JUSTIFICATION:

The existing NASA physical plant is necessarily impacted by changing utilization and adaptions required by changing technology and mission needs, as well as by new facility requirements generated by research, development, test, and like activities. Items included in this project reflect work which must be provided for during the period July 1, 1976 - September 30, 1976 to meet general NASA installation requirements or technical facility needs.

This work is not solely or primarily required to support specific research or development programs. However, included are those items which are required to meet the particular needs of one or more specific research or

development programs and which can be adequately identified at the time of submission of this budget estimate. Items of work proposed to be accomplished within this program during the quarter year have been carefully selected from a list totalling 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 this quarter 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:

Tentative subprojects of work to be considered for accomplishment under this estimate are outlined under "PROJECT COST ESTIMATE" and total $2,950,000. Of this total, $2,000,000 represents discrete work packages all of which reflect requirements at designated NASA field installations which were not included in prior year budget estimates. An additional amount of $500,000 is included for the accomplishment of projects which had previously been scheduled in prior year budget estimate but which could not then be undertaken due to the need to revise the listing of work to be accomplished within the allocated resources for a given fiscal year. These revisions are in keeping with the basic intent of this program and allow for the accommodation of urgent but unforeseen facility project work which could not fully qualify for accomplishment under Section 1(g) as unforeseen programmatic needs. Also included is $450,000 as a "lump sum" amount to provide for facilities work of these types (new construction and additions) estimated to cost not in excess of $50,000 for each project.

Minor Construction
July 1, 1976 - September 30, 1976

PROJECT COST ESTIMATE:

A. Ames Research Center $155,000

1. Addition to the Space Suit Physiology Laboratory, Building N-239A 75,000

This project provides for the addition of a mezzanine deck of approximately 1,500 sq. ft. (139 m^2) over existing environmental chambers which will adjoin the present mezzanine office area of the life sciences high bay, Building N-239A. By extending the new passageway via a catwalk with a railing, a second exit stair will be provided for both the new laboratory spaces and the existing offices. A new heating-cooling system will be provided. Existing water and fire protection sprinkler system will be extended to the new facility. These new laboratories will primarily be utilized to support a vastly expanded program of space suit investigations into the mechanisms of metabolic and thermal control, and fluid balance and electrolyte shifts within the body as influenced by the existing space suits and their life support systems. Secondarily, these new laboratory spaces will accommodate the laboratories located in Building 239 which will be lost as a result of an urgent requirement to expand the Human Research Facility which again, is in direct support of the space shuttle program.

2. Addition to Shop Area of the Arc Jet Laboratory, Building N-238 80,000

This project provides an "L"-shaped addition of approximately 1,800 sq. ft. (167 m^2). Approximately one-third of this space is devoted to laboratory space for instrumentation and calibration and the remainder for model preparation. These activities are presently located in Building N-238 which is too small for these functions. In addition, the personnel working in this area experience work interruptions because the area must be cleared during Arc Jet operation. The Interaction Heating Shuttle Panel Test Facility is currently operational with the test time of the arc increased from a minute to 30 minutes or more. Safety and efficiency considerations require that a safe work area, separated from the arc jet operation, be provided. The facility supports space shuttle and high reynolds number military research, and includes the giant planet pilot program.

B. Goddard Space Flight Center $595,000

1. Addition to the Environmental Testing Facility, Building 10 245,000

This project provides for the construction of a 7500-sq. ft. (697 m^2) addition to the Environmental Testing Facility, Building 10 for about fifty Systems Reliability Directorate personnel. This addition, which provides 4000 sq. ft. (372 m^2) of office space and 3500 sq. ft. (325 m^2) of laboratory space, will support the planned relocation of these personnel which in turn permits the consolidation of the now fragmented Quality Assurance Division and the parent Directorate into two facilities. Such relocation will permit a more effective use of the available space, eliminate current difficulties resulting from communications and coordination problems between organizational elements, and will provide for a more effective and functionally efficient operation. Included in this addition will be partitioning, lighting, heating, ventilating and air conditioning, rest room facilities and utilities to meet the requirements of the functions being consolidated in Building 10. The space being vacated will be utilized by personnel in the Projects Directorate who are presently housed in leased space.

This project is the second phase of a GSFC long term program undertaken in fiscal year 1975 to significantly improve the utilization of available space at the Center. The first phase involved the modification of three separate facilities totaling approximately 65,000 net sq. ft. (6039 m^2) of office, laboratory and storage space at a cost of $890,000. It is anticipated that additional resources may be required in subsequent years for further improvement in space utilization necessary to properly accommodate the Center's changes in workload and manpower requirements.

2. Construction of Display Area Adjacent to Space Projects Building 1 105,000

This project provides for the construction of a 3,600-sq. ft. (334 m^2) partially enclosed area adjacent to Building 1 for the display of space oriented exhibits. The large number of visitors justifies the need for a display area where visitors can view flight hardware and spacecraft exhibits. The need for this facility will become more pressing due to the expected increase in visitors during the 1976-1977 time frame.

3. Construction of Addition to Instrument Construction and Installation Laboratory, Building 5 245,000

This project provides for the construction of a 6,000-sq. ft. (558 m^2) mezzanine addition over the south wing of the Instrument Construction and Installation Laboratory, Building 5. A structural steel and concrete mezzanine is planned with partitions and finishes suitable for the laboratory and office occupancy. The mezzanine will enable the relocation of various elements of the Sounding Rocket Division of the Engineering Directorate into a centralized location. This project will provide for more efficient operation of the sounding rocket program which encompasses activities from project initiation through launch in support of scientific and applications research.

C. Jet Propulsion Laboratory $480,000

1. Construction of Addition to Lumber Storage Building, Building 234 105,000

This project will provide for approximately 1,200 square feet (110 m^2) of additional area at the east of Building 234 plus rearrangements to a 250-square foot (23 m^2) existing locker room in Building 234. The project will substantially improve working conditions for many of the craftsman at JPL by providing a badly needed rest room and clean up facility, isolated work areas for foremen, a lock and key shop and replacement of old locker equipment with modern, adequate change facilities. Construction will be single story, slab floor and concrete block walls to match the existing building. A metal pan and lightweight concrete roof will carry a hot mopped moisture barrier. Rest rooms, shower and change areas will be standard industrial construction and afford reasonable privacy for the men. This work is required because there are no rest room facilities on the first floor of the Carpenter Shop, Building 201, or in the Storage Building 234. Some 20 to 30 craftsmen work out of these areas and are forced to use very minimum change facilities and have no "wash up" capability available to them. Nearby office facilities are occasionally used, resulting in excessive dirt and maintenance costs. The lock and key shop needs to be relocated for supervision and efficiency in operation. The men need a "headquarters area" with sufficient rest room facilities, larger lockers that are adequate for a man's effects, and a place with reasonable privacy to clean up at the end of the day.

2. Construction of Cast and Cure Building No. 1 for Solid Processing Line, Edwards Test Station (ETS) 165,000

This project provides for the construction of a 500-square foot (46.5 m^2) standard metal structure. The building will be constructed over a concrete floor slab and will contain a centrally located underground curing oven. The mechanical equipment will occupy an area of 160 square feet (14.9 m^2), and the solid fuels casting and curing operations will be located in an area of 340 square feet (31.6 m^2). The underground curing oven is temperature controlled between 50°F (10°c) and 200°F (94°c) using hot or chilled circulating water and fans. A monorail crane provides for handling of the motor cases and their insertion into the below floor oven. The facility will be ventilated only. The project includes extension of the required access roads, underground extension of the ETS supporting utilities, and relocation of perimeter fencing as required by appropriate safety manuals. Present composite base solid propellants cannot supply the specific impulse requirements for future planetary missions of the series but the new double base systems theoretically are able to accomplish this.

The new propellant systems are hazardous to process and the size requirements for retro motors increase with spacecraft weight and trajectory velocity. Development work is necessary to prove the practical feasibility, of the theoretical projection, in full scale motors. This facility will permit the test program to be implemented in direct support of long-range requirements.

3. Construction of Two Oxidizer Operations Buildings, Edwards Test Station (ETS) $210,000

This project provides for the construction of the following two small buildings: (1) 330-square foot (30.7 m^2) building for oxidizer grinding, and (2) 720-square foot (67.0 m^2) building for blending/drying operations. An access road, utilities and fencing will also be provided. The buildings will be constructed of concrete block and each will have a "blow out" wall. Both buildings will be insulated and temperature stabilized using hot water heating and direct expansion cooling equipment. Necessary safety items, sprinklers, cleaners and exhaust systems are part of this project. These two small grinding and blending/drying facilities are being planned as the "batch production" sites for double base propellants at the Edwards Test Station. These propellants are coming under intensive R&D development as being required for retro motors on the long-range requirements. 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.

D. Johnson Space Center 160,000

1. Construct Storm Drains, 400 Area 160,000

This project provides for improving the storm water drainage system in the center support area of JSC. The work includes installing a subsurface storm sewer pipe system, regrading existing swales, constructing new swales, installing area inlets, and paving an outfall structure at the discharge point of this system into ditch 26. The storm sewer system is required to alleviate ponding and vegetation growth which is hampering ground maintenance in this area and which is contributing to excessive mosquito breeding.

E. Langley Research Center 280,000

1. Addition to the Plant Safety Building, Building 1248 200,000

The health facility to be constructed under this project will provide space for administrative activity, treatment of minor illnesses and injury, performance of job-related and preventive physical

examinations, and emergency services. The construction will be of concrete masonry units and brick - a 4,000-square foot (372 m^2) addition to Building 1248. The addition is proposed to provide for centralized emergency and occupational health activities. The various facets of health services at Langley are currently dispersed at locations that make coordination and communication difficult and sometimes delayed. The facility will enable upgrading medical functions to present-day needs and recognized standards. Coordinated rapid response to emergencies will be achieved through the improvement of centralization of emergency teams. Ambulance drivers, nurses, and fire-fighting personnel will all be dispatched to an emergency scene from a single location, and health personnel may be trained with immediate availability to their duty station.

2. Addition to 8-Foot High Temperatures Structures Tunnel (HTST), Building 1265 $80,000

The work consists of a single story addition to the southwest corner of the office portion of Building 1265, to add approximately 1,600 square feet (148 m^2) of space to the building. The addition will match the existing building in design and construction. The existing office space in B-1265 was designed to serve the minimum needs of personnel conducting aeronautical research in the 8-Foot HTST. Recently, with the addition of the thermal protection system test facility to the 8-Foot HTST complex, and the full dedication of both these facilities to shuttle development, on a multiple shift basis, it has become necessary to increase the staff for the operation of these facilities beyond the capabilities of the available office space in B-1265. At present, some of the professional staff are housed in substandard office space provided by two trailers adjacent to the building.

F. Tracking and Data Acquisition Stations 330,000

1. Construction of Ground Improvement Structures at Madrid Complex 330,000

This project provides for the installation of approximately 9,800 feet (3,000 meters) chain link fencing approximately 7 feet high (2.1 m) around the perimeters of the three stations at the Madrid complex. Perimeter lighting on 20-foot (6 m) poles which are 80 feet (25 m) apart will be installed. The stations, at the present time, have perimeter wire strand fence to keep cattle out. However, chain link fence is required to prevent inadvertent or deliberate intrusion by people.

a. DSN Madrid (2 stations) (200,000)

b. STDN Madrid (1 station) (130,000)

G. Various Locations $500,000

To provide for the accomplishment of project work which had prevously been scheduled but which could not then be undertaken due to the need to revise the listing of work to be accomplished within the allocated resources for a given fiscal year.

1. Addition to Materials Science Laboratory, Building N-240, Ames Research Center (240,000)

The project is a single story building addition to the High Bay of the Material Science Laboratory, Building N-240. The addition will provide approximately 6,000 square feet of office, graphics and computer related equipment areas for research scientists and support personnel of the Ames Computational Fluid Dynamics Branch. The project includes building site work and extension of utility lines into the addition, as well as complete mechanical and electrical.

Approximately 33 research scientists are now associated with the Ames Computational Fluid Dynamics Branch, studying various aerodynamic problems of National interest; these studies are largely based upon numerical simulation and visual display of flow fields about appropriate objects. At present, this group and the graphic equipment required for visual simulation and analysis work, is housed in the Central Computer Facility which is already overcrowded. By the end of FY 1975 about 50 people will be attached to this group and, similarly, the necessary graphic and related equipment will about double. It is also anticipated that Central Computer Facility hardware will expand by that time. The proposed addition, supplemented by the existing office and laboratory spaces on the second floor of Building N-240, is necessary to relieve this congestion. Further, designing the project to accommodate the essential graphic and related equipment, will result in improved equipment and personnel effectiveness in analyzing data from the Central Computer, ILLIAC IV, and other computers which provide the calculations comprising an integral part of this group's research efforts.

2. Addition to Blockhouse, Launch Complex 36, Kennedy Space Center (225,000)

This project provides a 5,100 square foot (474 square meters) addition to the blockhouse annex of the Atlas Centaur Vehicle Launch Complex 36, Eastern Test Range. This addition will permit consolidation of engineering personnel in the blockhouse annex and enable the release of 14 trailers presently utilized by the personnel at the blockhouse.

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3. Addition of the Helium Distribution System Helium Gas Holder, Building 121, Lewis Research Center ($35,000)

This project will provide for the construction of 1,500 linear feet of underground 4-inch line for transporting helium gas (resulting from boil-off of liquid helium used in Engine Research Building (ERB) research facilities) directly to helium purification, storage, and reliquification equipment located adjacent to helium gas storage container holders, Buildings 121 and 122.

The existing helium gas holder, Building 120, adjacent to the Engine Research Building 5, has deteriorated and is in need of replacement unless other helium recovery measures are instituted. The proposed line will not only replace the holder, Building 120, but will also eliminate the costly and time consuming present procedure of collecting the helium in the holder, pumping it into a tube trailer, and then transporting it to Buildings 121 and 122 for temporary storage. Further, the present method of handling the helium results in contamination which would be eliminated by use of the direct pipeline proposed.

MISCELLANEOUS PROJECTS LESS THAN $50,000 EACH	450,000
TOTAL	$2,950,000

FUTURE CoF ESTIMATE FUNDING REQUIRED TO COMPLETE THIS PROJECT:

It is estimated that between $4 million and $6 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 1976 ESTIMATES

SUMMARY

Facility Planning and Design
FY 1976

	Amount	Page No.
Regular Requirements:	$5,375,000	
Master planning	225,000	CF 7-2
Engineering support	875,000	CF 7-3
Preliminary engineering reports and related engineering studies	1,125,000	CF 7-5
Final design	3,150,000	CF 7-5
Other Requirements:	3,900,000	
Shuttle facility planning and design	3,440,000	CF 7-6
Spacelab/payloads planning and design	460,000	CF 7-7
Total FY 1976	$9,275,000	

Transition Period
July 1, 1976 - September 30, 1976

Regular Requirements:	1,950,000	
Master planning	125,000	CF 7-9
Engineering support	655,000	CF 7-9
Preliminary engineering reports and related engineering studies	570,000	CF 7-11
Final design	600,000	CF 7-11
Other Requirements:	850,000	
Shuttle facility planning and design	850,000	CF 7-12
Total, Transition Period	$2,800,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1976 ESTIMATES

PROJECT TITLE Facility Planning and Design	
FY 1976 CoF ESTIMATES $9,275,000	
FY 1974 $13,600,000	FY 1975 $10,900,000

The funds requested in this estimate are required to provide for the following advance planning and design activities related to facilties activities and projects:

a. The accomplishment of necessary development and master planning for field installations and, where not otherwise provided for, the updating of record drawings and the provision of engineering services.

b. The preparation of preliminary engineering reports, cost estimates, and design and construction schedules.

c. The preparation of final construction contract 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.

The $9,275,000 requested for facility planning and design for FY 1976 is composed of two major segments:

a. Regular requirements - $5,375,000

b. Other requirements - $3,900,000

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.

These large projects require significantly more planning and longer lead time than is normally involved. This planning must be completed prior to inclusion of the project in a budget request, consequently, most of these projects represent a continuing effort from previous years rather than new work. For this reason, the budgetary needs for this segment of facility planning and design reflect a significant reduction over funds required in the previous year.

1. REGULAR REQUIREMENTS

A. Master Planning $225,000

This segment of the requirement includes the necessary provisions to update and further develop 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 documentation on 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 three-year intervals. Approximately one-third of the field installations are involved in any one fiscal year, keeping the level of effort relatively 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 1976 are:

(1) Flight Research Center

The updating of the existing Master Plan to reflect current space shuttle modifications and also the latest changes in land uses.

(2) Johnson Space Center

The initiation of shuttle-related changes in programmatic assignments for the Center following the Apollo Soyuz mission and the updating of the existing plan to reflect these changes.

(3) Ames Research Center

An update for the existing plan to incorporate possible "land trade" activities between the Center and Pacific Gas and Electric Company

in connection with anticipated modifications to the 40' x 80' wind tunnel. It will include pertinent planning used in E.O. 11724 land utilization survey and will also incorporate current changes in the existing five-year plans and programmatic assignments.

(4) White Sands Test Facility

Studies are required to provide an updated inventory to reflect space shuttle modifications and incorporate the current facility plans into the standard approved format.

B. Engineering Support $875,000

Provisions for facility studies and specific engineering support have taken on an added importance in recent years, and must continue to be given high priority throughout FY 1976. These efforts are of upmost importance due to the more unpredictable cost situation which currently exists and recent cost trends in construction materials, fuels, and operation and maintenance cost for the physical plant. This also includes provisions for establishing and 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 1976 requirements:

(1) Value Engineering, Cost Validation and Analysis

This will provide for the procurement of 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 facility costs which will aid in resource planning for the various field installations.

(2) Building Research and Advisory Board Support

This covers annual support to the Federal Construction Council (FCC) operations and provides for special studies that this Council will perform throughout FY 1976 to help advance the science and technology of Federal Goverament building and construction. The FCC is a committee of the Building Research Advisory Board (BRAB), National Academy of Sciences.

(3) Utilities Services/Rates Analysis

This provides for the continued services of utility rate analysis support, to include counseling, surveillance, and agency-wide recommendations with regard to utility rates, contract negotiations and systems operations. This has become of increasing importance in light of the rapid increases in utility costs and supply problems.

(4) Design Specifications Update and Support

This provides continued engineering services for updating and operating the agency-wide construction specification system which combines a catalog of preapproved standard construction specifications on magnetic tape and a computer software program for selective retrieval and taped printouts of bid specifications.

(5) Minor Facility Project Update and Support

This will provide engineering services for the agency wide facilities information system for all facility projects from inception through design and construction. This system has the capability of providing all pertinent information on projects including priority assignments, technical information, cost estimates, schedules, etc., and providing a continuous "overview" to assisting management in making timely project and program decisions. This system also provides as a by-product, a solid accessible method for storage of historical data on facility projects.

(6) Engineering Handbook Update

The Facilities Engineering Handbook is a document prepared by Headquarters, to guide the field installations on a standardized approach. to facilities engineering, These handbooks are used as policy and criteria for all in-house engineering as well as work done by Architectural-Engineering firms. Since new criteria is constantly being developed and/or corrected, the handbook must be modified accordingly.

(7) Facility Operation and Maintenance Analysis

This provides for engineering support in implementing, at field installations, recommendations of previous effort concerning manpower utilization, work control systems, preventive maintenance, and financial management and reporting. This also provides for limited operation and maintenance management surveys to be conducted on a priority basis, at selected NASA field installations.

(8) Energy Reduction Analysis and Support

This provides for the continuation of engineering services to establish both immediate and long range energy conservation criteria for the operational management and design of commercial-type buildings, coincident with validation of an energy computer modeling program. This project will provide instrumentation and computer modeling at selected Centers and expand the types of structures being tested. This is a continuation of an existing program of developing substantive energy conservation design criteria and operational procedures for existing standard-type buildings.

C. Preliminary Engineering Reports and Related Engineering Studies $1,125,000

(1) Preliminary Engineering Reports (725,000)

Preparation of preliminary engineering reports (PER's), investigations, and project studies related to proposed facility projects to be included in the FY 1978 Construction of Facilities program 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 non-space shuttle construction involving and estimated cost of $25 million to $30 million of construction for which updated PER's will be needed and with new projects estimated to cost $20 million to $25 million for which complete new PER's will be required.

(2) Related Engineering Studies (400,000)

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 chemical waste disposal, utility control systems improvements, and miscellaneous energy and 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 $3,150,000

The amount requested will provide for the preparation of designs,

plans, drawings and specifications necessary for the accomplishment of non-space shuttle facility projects, primarily those which are planned for inclusion in the FY 1977 Construction of Facilities program. This request will provide for final design work associated with such proposed subsequent construction of this nature estimated to cost $35 to $40 million. It will also provide for residual requirements of this nature which have accumulated from prior years final design activities.

Subtotal, Regular Requirements $5,375,000

2. OTHER REQUIREMENTS

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 added 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 over and above the regular and the more recurrent facility planning and design needs covered above.

A. Shuttle Facility Planning and Design $3,440,000

(1) Shuttle Facilities Studies and Preliminary Design (440,000)

This portion of the total space shuttle facility requirement is associated with the preparation of preliminary engineering reports (PER's), the conduct of facilities investigations and the studies for facilities projects to be included in the FY 1978 Construction of Facilities program. This preliminary work is associated with future construction for that year now estimated to cost in the range of $50 to $55 million and is to be carried out in relation to space shuttle related projects such as:

(a) Launch and Landing Facilities

Additional studies will be conducted and PER's will be implemented towards modifying existing facilities, to satisfy refurbishment and logistics facility requirements at the launch and landing complex. Further studies will be needed to better define the facility needs as they relate to higher launch rates and to implement value engineering in the high value projects.

(b) Solid Rocket Booster Facilities

Studies and PER's will be continued toward modifying existing facilities or providing added capabilities for the solid rocket booster production as they relate to satisfying increased production requirements.

The cost of these related studies/engineering reports is estimated at $100,000 and the estimated cost of preparing preliminary engineering reports (PER's) is $340,000.

(2) Shuttle Facilities Final Design ($3,000,000)

This portion of the total facility planning and design requirement for space shuttle facilities is associated with the preparation of final design, drawings and specifications required for the proposed subsequent construction of space shuttle facilities, now estimated to cost $65 million to $70 million, and which may be included in a FY 1977 Construction of Facilities request. This design effort is mainly related to the second phase of the launch and landing facilities at Kennedy Space Center required to support the higher launch rate. It is directed toward preparation of final design drawings and specifications for the additional launch facilities needed to support the initial launch capability and higher flight rate particularly the second pad, mobile launch platform and vehicle assembly building required to support recovery operations at Kennedy Space Center. Also included is design for certain ground test facilities and manufacturing and final assembly facilities at MAF required for the greater production rates.

B. Spacelab Payloads Planning and Design $460,000

This planning requirement is related to the study, preliminary engineering and final design of initial facilities necessary to support the spacelab and payloads programs. These programs are essential to provide the capability for conducting science, application and technology missions. In addition, increased facilities are anticipated to be needed for launch, operation and experiment installations and integration activities. These facilities are now estimated to cost $5 million to $7 million and it appears will be needed in the FY 1977 construction of facilities time frame. The cost of these studies and preliminary engineering effort is estimated at $100,000 and the final design is estimated at $360,000.

Subtotal, Other Requirements	$3,900,000
Total FY 1976 Request	$9,275,000

CONSTRUCTION OF FACILITIES

July 1, 1976 - September 30, 1976 Estimates

PROJECT TITLE Facility Planning and Design	
July 1, 1976 - September 30, 1976 CoF Estimates $2,800,000	
FY 1975 $10,900,000	FY 1976 $9,275,000

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 updating of record drawings and the provision of engineering services.

b. The preparation of preliminary engineering reports, cost estimates, and design and construction schedules.

c. The preparation of final construction contract 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 $2,800,000 request for facility planning and design for July 1, 1976 - September 30, 1976 is composed of two major segments:

a. Regular requirements $1,950,000

b. Other requirements $850,000

Regular requirements encompass the basic purpose 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. These larger projects require significantly more planning and longer lead time than is normally involved. This planning must be completed prior to inclusion of the project in a budget request, consequently, most of these projects represent a continuing effort from previous years rather than new work.

1. REGULAR REQUIREMENTS

A. Master Planning $125,000

This segment of the requirement includes the necessary provisions to update and further develop 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 documentation on 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 three-year intervals. Approximately one-third of the field installations are involved in any one fiscal year, keeping the level of effort relatively 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.

(1) Kennedy Space Center

A major master planning and associated facility utilization study will be needed to fully explore and document the various aspects of land/facility use changes and building space consolidations necessary for KSC to most effectively accommodate the refined definition of the impacts and programmatic/functional requirements of the space shuttle.

(2) Downey NASA Industrial Plant

A major update of the existing Master Plan which will incorporate the various modifications and changes in facility and land utilization to provide for space shuttle orbiter production, to develop a statistical/narrative inventory of existing manufactoring capabilities, and to refine planning which will accommodate probable future shuttle-related manufacturing needs.

B. Engineering Support 655,000

Provisions for facility studies and specific engineering support have taken on an added importance in recent years and with current budget limitations must continue to be given high priority. These efforts are of upmost importance due to the unpredictable cost situation which currently exists and recent cost trends in construction materials, fuels and operation and maintenance cost for the physical plant. This also includes provisions for establishing and maintaining a current engineering data base and updated performance specifications for utilization by the various field installations. The following items are included in these requirements:

(1) Value Engineering, Cost Validation and Analysis

This will provide for the procurement of 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 facility costs which will aid in resource planning for the various field installations. This procurement will be required during the transition period although the related work will not actually be executed until the following fiscal year. Therefore, resources will be needed in this time frame to award contracts for the related work.

(2) Building Research and Advisory Board Support

This covers annual support by NASA as a participating agency to the Federal Construction Council (FCC) operation and provides for special studies that this Council will perform throughout Fiscal Year 1977 to help advance the science and technology of Federal Government building and construction. The FCC is a committee of the Building Research Advisory Board (BRAB), of the National Academy of Sciences.

(3) Design Specifications Update and Support

This provides continued engineering services for updating and operating the agency-wide construction specification system which combines a catalog of preapproved standard construction specifications on magnetic tape and a computer software program for selective retrieval and taped print-outs of bid specifications. Although much of the work will be executed during the following fiscal year, resources will be required in this time frame to allow for procurement of contract services to accomplish the work.

(4) Minor Facility Project Update and Support

This will provide continued engineering services for inputing current information on minor facilities projects into an ongoing computerized agency-wide information system and for operating this system for all field installations throughout a major portion of the following fiscal year.

(5) Energy Reduction Analysis

This will provide engineering services to develop utility control techniques applicable to all field installations and will serve as an agency-wide guide when future utility conservation measures are enacted.

(6) Cooling Tower/Boiler Treatment Study

This provides for engineering support necessary to examine treatments for cooling towers and boilers at the various installations throughout the agency in order to reduce/eliminate current problems associated with these systems. This has become increasingly important in light of major problems recently experienced by several major field centers.

C. Preliminary Engineering Reports and Related Engineering Studies $570,000

(1) Preliminary Engineering Reports

Initiation of preliminary engineering reports (PER's), investigations, and project studies related to proposed facility projects to be included in subsequent 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 basic data, cost estimates and schedules related to any such future budgetary proposals. This request will provide for initiation of PER work associated with proposed subsequent non-space shuttle construction. The remaining funds required for completion of this cycle of PER effort will be included in the FY 1977 estimates.

(2) Related Engineering Studies

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 chemical waste disposal, utility control systems improvements and various energy and 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 600,000

The amount requested will provide for the initiation of designs, plans, drawings and specifications necessary for the accomplishment of non-space shuttle facility projects planned for inclusion in the FY 1978 Construction of Facilities program. This request will provide for initiation of final design work associated with proposed subsequent construction of this nature. The additional funds required to complete design of the FY 1978 non-shuttle program will be included in the FY 1977 Budget.

Subtotal, Regular Requirements $1,950,000

2. OTHER REQUIREMENTS

These other facilities planning and design requirements are generated by potential future projects, large in size and of a complex nature. These are associated with future space programs which require a long planning cycle. Early and progressive design work is essential to insure the ultimate best design, cost estimates and schedules. These projects then require planning effort and associated preliminary engineering reports greater than general type facility projects. For this reason, these requirements must be provided for over and above the regular and the more recurrent facility planning and design needs covered above.

A. Shuttle Facility Planning and Design $850,000

(1) Shuttle Facilities Studies and Preliminary Design (200,000)

This portion of the total space shuttle facility requirement is associated with the preparation of preliminary engineering reports (PER's), the conduct of facilities investigations and the studies for facilities projects to be included in the FY 1979 Construction of Facilities program. This preliminary work is associated with future construction for that year, now estimated to cost in the range of $45 million to $50 million and is to be carried out in relation to space shuttle related projects such as:

(a) Solid Rocket Booster Facilities

Studies and PER's will be continued toward modifying existing facilities or providing capabilities for the solid rocket booster production as they relate to satisfying increased production requirements.

Funds for completion of this study and preliminary design effort will be included in the FY 1977 budget.

(b) Launch and Landing Facilities

Additional studies will be conducted and PER's will be accomplished towards modifying existing facilities to better satisfy support facility requirements at the launch and landing site. Although no specific facilities have yet been validated for this time frame, it is felt that certain potential modifications have sufficient merit to warrant further studies to determine more cost effective methods of satisfying higher launch rates during the operational phase.

(2) Shuttle Facilities Final Design ($650,000)

This portion of the total facility planning and design requirement for space shuttle facilities is associated with the initiation of final design, drawings and specifications required for the proposed subsequent construction of space shuttle facilities, now estimated to cost $50 million to $55 million, and which may be included in a FY 1978 Construction of Facilities request. This design effort is mainly related to second phase of launch and landing facilities at Kennedy Space Center required to support the higher launch rate.

Funds for completion of this design effort will be included in the FY 1977 Budget.

Subtotal, Other Requirements	$850,000
Total for July 1, 1976 - September 30, 1976 Period	$2,800,000

PROGRAM LEVEL

Mr. TRAXLER. On page SUM 5, the table lays out the current NASA construction of facilities picture. The request for fiscal 1976 is $84,620,000, a decrease of $55,535,000 below the $140,155,000 appropriated for fiscal year 1975. An additional $14,500,000 is requested for the transition period. The $14,500,000 requested represents a full year level of $58 million. Does that suggest a continuing decline in NASA construction costs?

Dr. FLETCHER. Mr. Chairman, General Curtin, who is in charge of our facilities office, will be the witness this morning.

General CURTIN. No, Mr. Chairman, it does not. Going back to the basic program of $84 million, in our fiscal year 1976 request versus the $142 million in fiscal year 1975, the difference is made up essentially in the major discrete line items, split about 50–50 between the Shuttle facilities and the non-Shuttle discrete projects. The Shuttle reduction was largely attributable to adjustments in the intermediate milestones in the Shuttle program without any compromise of the end-position major milestones. We were able to defer some of that work, which will be reflected in future years.

CURRENT ESTIMATE OF FY 1977 REQUIREMENTS

Mr. TRAXLER. What do you anticipate that your fiscal 1977 request will be for construction of facilities?

Mr. LILLY. At this point in time, we estimate that it will probably be about $130 to $140 million.

PROPOSED APPROPRIATION LANGUAGE

Mr. TRAXLER. On page SUM 3, the proposed fiscal year 1976 language is outlined. You are requesting language that eliminates all dollar limitations by location and by project. Will you give the committee your views on why you feel this new language is important or necessary?

General CURTIN. Yes, sir.

Mr. Chairman, this language was arrived at after discussions with the staffs of both the authorization and appropriations committees. It reflects an understanding that the authorization would be delineated by line items, and that the documentation in support of that would be our basic point of departure and implementation. It also assumes that the committees would be advised of any major deviations.

Consequently, having different language and different limitations in an appropriation bill from those spelled out in the authorization bill was felt to be not warranted.

Mr. TRAXLER. No determination has been made by this subcommittee on how we will treat this language request. However, I think it is important to make clear that whatever the decision on the part of the committee, it is important that you recognize that the committee will place limitations on projects where the committee feels the facts require it.

General CURTIN. We understood that in our discussions, Mr. Chairman.

51-423 O - 75 - 41

REQUEST TO OMB

Mr. TRAXLER. What was your request of OMB for construction funds?

General CURTIN. Our fiscal year 1976 request to OMB was approximately $30 million higher than was allowed. I think it was $30.3 million higher. That made it $114.9 million, as I recall.

Mr. TRAXLER. Do you recall what items were dropped by yourselves or OMB in discussions and negotiations?

General CURTIN. Yes; the major item deleted was $21.2 million to start construction of a large, 64 meter antenna, which would provide a second large antenna at Goldstone and a fourth 64 meter antenna in the network. There was a $2.1 million adjustment in the Shuttle facilities program; $2.1 million for a proposed refuse-fired steam generating plant at Langley was deleted; $1.6 million for modification of a flight simulator at Ames Research Center; a $2 million reduction in rehabilitation and modification at various locations; and a reduction of $1.6 million in facilities planning and design.

NEED FOR FOURTH DEEP-SPACE ANTENNA

Mr. TRAXLER. Why had you requested another deep space network antenna? It would have been a fourth antenna?

General CURTIN. Yes; it would have been a fourth deep-space 64-meter antenna and a second one at Goldstone.

Mr. TRAXLER. What was the purpose of that?

Mr. TRUSZYNSKI. Mr. Chairman, in our current deep space network, we have three large antennas, one at each of three locations around the world. These are mainly for support of the planetary program. These programs involve spacecraft which travel to extreme distances, so we need large antennas to provide support for them.

When we looked ahead at the total mix of planetary programs under consideration, it was apparent that the workload would require additional antennas.

Mr. TRAXLER. This antenna would have been located at Goldstone?

Mr. TRUSZYNSKI. Yes sir, at our Goldstone Station in California.

SHUTTLE SHARE OF CONSTRUCTION BUDGET

Mr. TRAXLER. The Shuttle is absorbing about 55 percent of your total construction budget. Were there any projects dropped by OMB or NASA that you feel should have equal priority with Shuttle construction?

General CURTIN. I know of none. I will make this observation, Mr. Chairman. In the Shuttle program, in terms of determining the projects that must be included, they are very sensitive to the timelines that I referred to in my opening comments.

Each of these Shuttle facilities requirements have been tested against a need-date with the appropriate timelines reflected in the schedule, showing that they have to be in the fiscal year 1976 program. There is no direct competition, as I see it.

Dr. FLETCHER. In addition, since all of us were involved in the prioritization, if you were to slip Shuttle facilities, it would increase the overall costs in the R. & D. portion of our budget. That is a major reason why the Shuttle facilities, which must be available to meet need-dates, are high-priority.

CONSTRUCTION PRIORITIES

Mr. TRAXLER. Let's talk for a moment on that point. As we look at your priorities, with the exception of your wind-tunnel modifications at Ames, it would appear that aeronautics came out second best and that there is great emphasis on the Shuttle. Are you really satisfied with this balance?

Dr. FLETCHER. I am not necessarily satisfied with that balance. I think if we had additional dollars, we would add those additional dollars in programs other than the Shuttle, and aeronautics would rate very high on that list of priorities. But again, we have to worry about the taxpayer. If we delay the Shuttle facilities, it is going to increase the overall cost of the Shuttle program. We think that would not be a fiscally responsible approach.

PROGRESS ON PROJECTS

Mr. TRAXLER. Those are wonderful words. Can you update for us the table that appears on page 515 of last year's hearing and see that that gets submitted for our records?

Dr. FLETCHER. We will be glad to do that, Mr. Chairman.

[The information follows:]

As of March 10, 1975, the enclosed plan for fiscal year 1975 C. of F. projects applied. The plan supports and explains the $24.9 million obligated through January 31, 1975, and the planned obligation of $110.9 million through June 30, 1975. The plan is reviewed and revised progressively; however, any project which may "slip" from late fiscal year 1975 to early fiscal year 1976 obligation will be reflected as additive to the first quarter fiscal year 1976 schedule.

FISCAL YEAR 1975 CONSTRUCTION OF FACILITIES PROGRAM

[Thousands of dollars]

Location/title	Amount	Actual, as of Jan. 31, 1975		Estimated total, June 30, 1975		Estimated total, June 30, 1976	
		Obligations	Outlays	Obligations	Outlays	Obligations	Outlays
Ames Research Center: Addition to flight and guidance simulation laboratory	3,660	56	1	2,500	300	3,400	1,100
Goddard Space Flight Center	2,100	23	10	1,900	300	1,900	1,250
Rehabilitation and modification of science and applications laboratories	890	23	10	800	100	800	550
Modifications for fire protection and safety	1,220			1,100	200	1,100	700
Jet Propulsion Laboratory	8,820	4,880	326	8,030	1,000	8,230	4,750
Acquisition of land	150			150		150	150
Addition to systems development laboratory (SDL)	4,880	4,880	326	4,880	700	4,880	2,800
Addition for integrated systems testing facility	3,790			3,000	300	3,200	1,800

FISCAL YEAR 1975 CONSTRUCTION OF FACILITIES PROGRAM—Continued

[Thousands of dollars]

Location/title	Amount	Actual, as of Jan. 31, 1975		Estimated total, June 30, 1975		Estimated total, June 30, 1976	
		Obligations	Outlays	Obligations	Outlays	Obligations	Outlays
Johnson Space Center: Modification of water supply system	935	455		600	200	900	400
Langley Research Center	3,505			1,700	170	3,050	1,200
Modification of 6,000 lb/in² air storage system	515			100	10	450	300
Rehabilitation of 16-ft transonic wind tunnel	2,990			1,600	160	2,600	900
Lewis Research Center	3,240			2,870	330	3,020	1,300
Modification of propulsion systems laboratory	2,580			2,270	230	2,420	900
Modification of rocket engine test facility	660			600	100	600	400
Marshall Space Flight Center: Construction of X-ray telescope facility	4,060	2,896	70	3,200	700	3,900	1,900
Wallops Flight Center: Modification of beach protection system	1,370			1,000	200	1,200	600
Various locations:	7,470			6,300	600	6,700	3,800
Construction of infrared telescope facility, Mauna Kea, Hawaii	6,040			5,500	500	5,500	3,300
Modifications for fire protection and safety at various tracking and data stations	1,430			800	100	1,200	500
Space Shuttle facilities	77,185	11,785		63,900	7,000	74,900	36,800
Construction of orbiter landing facilities, KSC	15,880	6,034		12,600	4,400	14,100	7,200
Construction of orbiter processing facility, KSC	13,380			11,000	400	13,300	6,600
Modifications to launch complex 39, KSC	35,355			28,800	400	35,000	17,000
Modifications for dynamic test facilities, MSFC and NASA Industrial Plant, Downey, Calif	3,920	3,134		3,800	500	3,900	1,800
Construction of orbiter approach and landing test facilities, FRC	2,940			2,700	400	2,900	1,400
Modifications for crew training facilities, JSC	420			400	100	420	250
Modification of the vibration and acoustic test facility, JSC	410			300	100	400	200
Construction of materials test facility, White Sands test facility	790	617		700	400	790	350
Modifications for solid rocket booster structural test facilities, MSFC	2,590	2,000		2,600	100	2,590	1,400
Construction of Shuttle/carrier aircraft mating facilities, various locations	1,500			1,000	200	1,500	600
Rehabilitation and modification	14,900	3,385	250	10,000	2,100	12,300	8,000
Minor construction	4,500	194		2,900	300	3,500	2,500
Facility planning and design	10,900	1,210	145	6,000	900	7,100	5,500
Total	142,655	24,884	802	110,900	14,100	130,100	69,100

SPACE SHUTTLE FACILITIES

Mr. TRAXLER. Let's turn to the justifications by location and go first to the Space Shuttle facilities. On page CF 4–1, the justifications indicate that through fiscal 1975, $202,635,000 has been approved for the Space Shuttle C of F funding. For fiscal year 1976 you are requesting an additional $47,220,000 for a total of $249,855,000. I think your initial Shuttle facilities requirement is estimated at about

$300 million, plus inflation. That means another $50 million-plus should complete the Shuttle construction requirements.

General CURTIN. The dollars reflected here, of course, are in dollars of the fiscal year 1976 budget. The $300 million cost estimate is in terms of 1971 dollars. If we were to take the fiscal 1976 budget dollars and reconcile them to the 1971 dollar estimate, they equate to about $195 million in 1971 dollars. So in terms of 1971 dollars, we have about $100 million to go against the $300 million estimate in 1971 dollars.

FUTURE REQUIRMENTS FOR SHUTTLE

Mr. TRAXLER. Do you anticipate that you are going to fund the balance of this next year?

General CURTIN. No, sir. The actual scheduling of the facilities for the Shuttle, as we now see them, would be over the next several years, not just in 1 fiscal year.

TOTAL SHUTTLE FACILITIES COST ESTIMATE

Mr. TRAXLER. What do you antcipate the total construction costs for the Shuttle will be?

General CURTIN. Based the dollars of the fiscal year 1976 budget, it would be $395 million, as I recall the estimate.

TIMING OF SHUTTLE FACILITIES

Mr. TRAXLER. On Page CF 4–2, you indicate that Shuttle facilities have to be completed 6 to 12 months before the first manned orbital flight. That will take place in the second quarter of calendar 1979. If the fiscal year 1976 request is approved, NASA will have about 80 percent of the Shuttle construction funds required.

Isn't your current schedule runing ahead of the 6 month completion requirement before the first manned orbital flight?

General CURTIN. No; Mr. Chairman. I think the question of timing has to be considered in relation to each individual item. In most of these items, particularly those at Cape Kennedy relating to the first manned orbital flight, there is a 12- to 14-month activation and checkout period required in order to give confidence in the overall system. There is a very intense period of work required after completion of the facilities and prior to the first flight.

SHUTTLE LANDING FACILITIES AT KSC

Mr. YOUNG. Mr. Chairman, before you get too far away from page CF 4–1, I would like to ask a question.

Mr. TRAXLER. Go right ahead.

Mr. YOUNG. On the second paragraph on CF 4–1, you talk about the facilities at John F. Kennedy Space Center, and you say that "In fiscal year 1976 the Shuttle facilities are again primarily for launch and landing requirements." Is it planed to land the Shuttle at the Kennedy Space Center?

Mr. TRAXLER. That is correct.

Mr. YOUNG. Will it be there? Where will it be located?

General CURTIN. The landing field is presently under construction and progressing well. It is located to the north and slightly to the west of the Launch Complex 39 Vehicle Assembly Building that was provided in prior years' programs. The contract has been awarded and construction is moving along. There will be a 15,000-foot runway, essentially the same type as you might expect at a large airport.

Mr. YOUNG. Thank you.

MODIFICATIONS TO LAUNCH COMPLEX 39

Mr. TRAXLER. On page CF 4–5, the justifications outline the $13,110,000 requested for the continued modifications to Launch Complex 39 at Kennedy Space Center. The justification states that these funds continue work underway over the past 2 fiscal years. Last year, on page 752 of the hearings, you indicated that it would cost an additional $52 million to complete Launch Complex 39. When you deduct the $13 million requested for fiscal year 1976, that should leave a balance of about $39 million. However, on page CF 4–8, you are now indicating that $55 million to $65 million will be required to complete the work. Can you tell us how this estimate got $20 million to $25 million higher?

General CURTIN. Mr. Chairman, the figures you state are correct. There has been some reappraisal and reevaluation of the actual work to be accomplished, primarily on the pad and the mobile launcher.

These are updates of the prior years' pricing, but still within the total program amount that we have previously planned for Kennedy. It is an overall programmatic adjustment in the costs and an update, which incorporates the impact of a $7.3 million cut in our fiscal year 1975 appropriations available. As a result, the total estimate is about $12 million higher than stated last year.

Mr. TRAXLER. On that same page, CF 4–8, you indicate that the additional funds required are for a second pad, a second mobile launcher, and two more bays.

General CURTIN. That is correct.

Mr. TRAXLER. Will that work have to be completed prior to the first manned orbital flight in the second quarter of calendar 1979?

General CURTIN. No, Mr. Chairman.

SCHEDULE FOR COMPLETION OF SECOND LINE AT LAUNCH COMPLEX 39

Mr. TRAXLER. When will that be completed?

General CURTIN. I do not have a precise schedule with me but I can furnish it for the record. It is downstream.

You are speaking now of the second mobile launcher and the third and fourth bay and the high bay.

Mr. TRAXLER. Yes.

General CURTIN. I do not have that schedule but I can furnish it for the record.

[The information follows:]

Under our current planning construction of the second pad, second mobile launcher and two high bays of the Vehicle Assembly Building are scheduled to be completed in late 1980. Following construction, extensive activation of these

facilities will take place with operational capability being attained in late 1981/early 1982. Once operational, these facilities will provide the capability for supporting higher launch rates.

MODIFICATIONS TO LAUNCH CONTROL CENTER

Mr. TRAXLER. On page CF 4–7, there is a discussion of the need to modify the Launch Control Center at Kennedy for the Space Shuttle. There is mention of modifying firing room 1 to accommodate DOD missions. That is at a cost of some $270,000. What are the modifications that you know of that are taking place there?

General CURTIN. It is primarily a shielding to make this room communication-secure to meet an Air Force requirement. That is the primary cost.

Mr. TRAXLER. Is this the one we talked about a day or so ago, the shielding necessary for security?

Dr. FLETCHER. I think that we talked about the Western Test Range a day or so ago. This one is at the Kennedy Space Center.

Mr. TRAXLER. Thank you.

General CURTIN. It is a minor portion of this work. It is being incorporated because of our general understanding with the Air Force that where we have common use of facilities, the host would provide that.

Mr. TRAXLER. Is there any charge-back arrangement with DOD on the costs?

General CURTIN. Not in this case. However, they would reimburse for unique Air Force facilities that are not jointly used.

ORBITER PROCESSING FACILITY

Mr. TRAXLER. On page CF 4–12, you are requesting $8,160,000 for the second year increment of the orbiter processing facility; $13,380,000 was provided for construction in fiscal year 1975 and prior years. Have you obligated any of the fiscal year 1975 funds to date and if so, how much?

General CURTIN. I would have to furnish that figure for the record, Mr. Chairman.

Mr. TRAXLER. Would you also advise us of how much will be obligated prior to the end of fiscal 1975.

General CURTIN. Yes; I have that information with me for the total program, but not the specific project.

[The information follows:]

Design funds for this project have been obligated and we are now proceeding as planned on this project and have completed the final engineering design. The major contract for construction should be awarded in early May 1975 with an estimated obligation of $11 million to $12 million at that time.

Mr. TRAXLER. Mr. Young.

ORBITER REPROCESSING ACTIVITIES

Mr. YOUNG. In the last paragraph on that page CF 4–12, you state, "Upon returning from a space mission, the orbiter must undergo 'safing,' maintenance and check-out operations before it can be ready for reuse."

Are we talking about prior to landing, or after landing and before taking off again?

Dr. Low. This is after landing, Mr. Young. After an orbiter lands, it will be processed through these facilities. It will be reprocessed, repaired, as necessary, and inspected and will be ready to fly again within 2 weeks.

Mr. YOUNG. Part of that is the "removal of ordnance." Is this ordnance that has been expended and is not reusable or that has to be maintained or go through a maintenance program? What kind of ordnance are you talking about removing?

Mr. YARDLEY. This is basically expended parts. We don't have very much ordnance used on the Shuttle.

Dr. Low. Would you define "ordnance," Mr. Yardley?

Mr. YARDLEY. The ordnance items are little igniters and pyrotechnic actuators, not big rockets.

Mr. YOUNG. Things that have been used but cannot be reused again?

Dr. Low. Yes, Mr. Young.

General Curtin would like to add a point on the chairman's earlier question.

General CURTIN. Mr. Chairman, going back to your question about obligations, the major construction would start in May of this year and be completed in May or June 1977, to give you a time frame for the total project.

SECOND PAD AND MOBILE LAUNCHER

Mr. TRAXLER. While we are on this justification, are the second pad and the second mobile launcher included in the total Shuttle construction costs?

General CURTIN. The second pad and second mobile launcher are included in the $300 million estimate in 1971 dollars; yes, sir.

MODIFICATIONS FOR SOLID ROCKET BOOSTER PROCESSING

Mr. TRAXLER. On page CF 4–18, you are requesting $5,240,000 to modify existing Air Force solid rocket motor facilities at Cape Canaveral. This is a new project and I understand that by modifying existing facilities, there may be some money saved. Can you give us some background on this and tell us what you hope to save?

General CURTIN. When the requirement was originally looked at, it was envisioned that we might have to build a new facility, fully funded by NASA. The estimate, as it initially emerged, was around $25 million. That was subsequently refined and scrubbed down to a range of approximately $15 million to $18 million. Then we found that we could, on reconsideration, modify the Air Force facilities. This is the broad order of magnitude.

Mr. TRAXLER. Does this put the Shuttle solid rocket assembly building somewhat farther away than originally planned?

General CURTIN. That is correct. But this is manageable and with the cost tradeoffs it becomes an attractive option.

MODIFICATIONS FOR HYPERGOLIC CHECKOUT AND REFURBISHMENT FACILITIES

Mr. TRAXLER. On page CF 4–25, the justifications discuss the modifications for hypergolic checkout and refurbishment facilities. The Congress has provided $6,233,000 for the construction of this facility. Can you tell us how much has been obligated of that?

General CURTIN. If I may, I would like to supply that information for the record.

Mr. TRAXLER. Please, and also identify the amount you expect to obligate by the end of the fiscal year.

[The information follows:]

The $6,233,000 referenced under the category of "construction" was not authorized for this project in support of the Space Shuttle program, but rather is the actual "book value" of the existing facilities. This complex was constructed in the early 1960's originally to support the Gemini program and subsequently was used through the Apollo era. There were no fiscal year 1975 construction funds provided for this project.

CONSTRUCTION OF ORBITER APPROACH AND LANDING TEST FACILITIES

Mr. TRAXLER. Turn to page CF 4–38, the orbiter approach and landing test facilities. As you are aware, this committee denied $1,940,000 requested for this project last year. In conference with the Senate, the committee agreed to provide those funds. However, the conference report states that construction could not begin unless NASA and the Air Force agreed on a total Shuttle facility plan at Edwards Air Force Base. NASA has since reached an agreement with the Air Force.

Do you believe that agreement incorporates a total Shuttle facilities plan at Edwards and can you briefly describe the plan for us?

Mr. YARDLEY. Our plan for Edwards is to use it as a test site for development of the Shuttle, both for the approach and landing tests, using the 747, and to land the first three to five development orbital flights there. From that point on, our plan is to use Edwards strictly as an emergency landing site. We determined that the facilities that were required for this testing were more than adequate for the emergency case. Therefore, the Air Force looked at it and agreed with us and said, "That is perfectly all right as far as we are concerned." The plan was coordinated.

I might mention that we conducted joint studies with the Air Force to see if it would be more economical to use Edwards instead of Vandenberg for the landing site for the west coast. It did not turn out to be less expensive, and it was not technically feasible for some of their mission plans.

NASA-AIR FORCE COORDINATION OF SHUTTLE FACILITIES

Mr. TRAXLER. Obviously it is the Congress' intent to avoid the duplication of landing facilities at Edwards, as you well know. Is the Air Force contemplating Vanderberg for the primary landing of its Shuttle?

Mr. YARDLEY. The Air Force has definitely decided to go to Vandenberg for its landing facilities for the Shuttle. That conclusion was part of the tradeoff studies that I just mentioned. The Air Force looked at landing at Edwards and ferrying the orbiter to Vandenberg and saving some money on the extension of the runway at Vandenberg; however, it would cost more money to keep a force at Edwards for this purpose than it would be to consolidate their operations at Vandenberg.

Mr. TRAXLER. Are you confident that there are not going to be two separate facilities constructed at Edwards?

Mr. YARDLEY. Absolutely, Mr. Chairman. We coordinated very closely with the Air Force, and we looked at all the available facilities at Edwards Air Force Base. Unfortunately, there are no hangars there that are adequate for the Shuttle that are not booked for about the next 10 years.

ORBITER APPROACH AND LANDING TEST FACILITIES AT FRC AND PALMDALE

Mr. TRAXLER. In addition to the $1,900,000-plus provided last year for the Edwards hangar, you reprogramed another million to offset the inflation in steel prices and some other modifications. Is the $1,680,000 requested this year strictly for nonhangar requirements?

General CURTIN. That is correct, Mr. Chairman.

The $1,680,000 requested is basically for the construction of a building to house the acceptance checkout equipment at Palmdale, and a microwave transmission system between FRC and Palmdale. The part that relates to the hangar will provide hazardous material storage facilities at FRC and is included at $320,000.

NO OVERLAP IN NASA-AF SHUTTLE FACILITIES

Mr. YOUNG. Is there much duplication between NASA and the Air Force in this program? In the last two questions and answers, we talked about the Air Force making certain decisions about the Shuttle program. Of course NASA makes major decisions. How much duplication is there in R. & D. planning or the development stage?

General CURTIN. I can speak to the facilities. I know of no overlap as far as the facilities are concerned. We have had frequent discusions with the Air Force at the facilities level. We coordinate with DOD on an annual basis in a very formal way. We exchange ideas and suggestions. We have Air Force officers working in my office, and also at Kennedy, not only to insure that there is no duplication but also so that the knowledge that we gain in building our facilities can be transferred to the Air Force for use at Vandenberg.

Dr. Low. Mr. Chairman, there is no duplication in any part of the Shuttle program. We are fully coordinated with the Air Force through the NASA-DOD Space Transportation System Committee which is cochaired by Mr. Yardley, NASA's Associate Administration for Manned Space Flight, and Assistant Secretary of the Air Force LaBerge. There are various panels under that coordinating group.

We also have Air Force officers working with NASA, and NASA people working with the Air Force, to be sure that we gain the maxi-

mum out of both organizations, without any duplication of effort. Mr. Lilly may want to discuss the coordination of facilities.

Mr. LILLY. Before we formally propose any construction programs, we have a formal transfer of our proposed budgets. We give DOD ours and DOD gives us theirs. There is a complete review and signoff before we ever finalize our construction of facilities programs. NASA and DOD have formal coordinating mechanisms to prevent any unwarranted duplication.

NASA-DOD ROLES

Mr. TRAXLER. So the relationship is that you are the developer of the Space Shuttle, but you keep them advised and they are going to use your system.

Dr. FLETCHER. Yes, Mr. Traxler. NASA manages and funds the Space Shuttle development. As you recall, DOD has agreed to fund development of the interim upper stage and the west coast Shuttle launch facilities at Vandenberg Air Force Base. The entire Space Transportation System effort is well coordinated and the roles are carefully delinated.

Mr. TRAXLER. Mr. Talcott.

FRC HANGAR REQUIREMENTS

Mr. TALCOTT. In spite of all this talk and the understanding of agreement between the Air Force and NASA and the Congress, another copartner in this effort, we had considerable misunderstanding last year about the hangar at Edwards. I am just woundering if we are all together this time so we will not have confusion on the floor and disagreement between the authorizing committee and our committee.

On page 2 of the agreement, NASA agrees to the construction of the hangar, 140 feet wide, 170 feet long and 60 feet high. I understand this will hold two orbiters, right?

General CURTIN. No sir. That is one orbiter, basically.

Mr. TALCOTT. That is pretty large for just one orbiter. What is all the extra space for?

General CURTIN. Whatever extra space is involved was originally envisioned for potential downstream payload removal and for ground support equipment to service the orbiter, Mr. Talcott.

ORBITER APPROACH AND LANDING FACILITIES AT PALMDALE

Mr. TALCOTT. Can we look at page CF 4–43, which shows the acceptance checkout equipment facility addition required at Palmdale?

General CURTIN. The drawing on page CF 4–43 is to show the part of this project that relates to the building for housing for the acceptance checkout equipment. It will be at AF plant 42, Palmdale, where the orbiter assembly will take place.

DIFFERENCE BETWEEN PALMDALE AND EDWARDS FACILITIES

Mr. TALCOTT. What is the difference between the Palmdale facilities and the ones at Edwards?

Dr. Low. The orbiter assembly and checkout facilities are located at Palmdale. The Space Shuttle parts, wherever they are built, will be assembled in Palmdale. There will be pieces built all over the country, and they will be brought to Palmdale for assembly and checkout of the complete orbiter. The approach and landing tests and initial development landings will occur at Edwards. There will be no flight operations as Palmdale. The hangar at Palmdale will be a checkout facility.

Mr. TALCOTT. What is the size of the facility at Palmdale? That looks like about the same size as the one at Edwards?

General CURTIN. It is a much larger facility, Mr. Talcott.

I do not recall the exact dimensions. I can furnish those for the record.

[The information follows:]

Upon completion of construction, the Palmdale facility (Building 294 at Air Force Plant 42) will contain 60,000 square feet of high-bay area and some 53,000 square feet of low-bay space, for a total of approximately 113,000 square feet of space. The high-bay space will be 300 ft. long x 200 ft. wide which is much larger than the FRC hangar sized at 175 ft. long x 140 ft. wide.

Mr. TALCOTT. So they are not comparable.

General CURTIN. No, sir, they are not.

Dr. Low. The addition at Palmdale to house the acceptance checkout equipment will be located adjacent to an existing building there.

Mr. TALCOTT. So we still need the other hangar at Edwards?

General CURTIN. That is correct.

Mr. TALCOTT. But it is not quite as large and will be a bare-bones type of thing?

General CURTIN. That is correct, Mr. Talcott. Bare-bones is a good expression.

Mr. TALCOTT. It is one that is always used here.

General CURTIN. We look at it as being an austere facility. A very conscious effort was made to keep the cost to a very minimum.

Mr. TALCOTT. This is just going to house one orbiter with very little other equipment there?

General CURTIN. Yes, sir.

POTENTIAL OF FRC HANGER

Mr. TALCOTT. Is the hangar designed so that in the future additions can be built on?

General CURTIN. The hangar could be most feasibly expanded in the longitudinal direction. As you recognize, the shop and other support space can also conveniently be expanded. We have looked at options of a different construction method to open up one side of the hangar and to be able to take care of larger wing span aircraft downstream, if this became necessary. But this is a poor tradeoff to building a new facility if you ever face that requirement.

Mr. TALCOTT. But this is the facility you need now. You don't contemplate future expansion based on current needs?

General CURTIN. No, sir. If the aeronautic programs, of course, develop beyond what we foresee at the present time we could come back and ask for some modification to this to fit into the overall facilities

support for the Flight Research Center, but we do not see that requirement at the present time.

Mr. TALCOTT. So in your opinion this hangar at the total cost of $2,940,000 is sufficient for the needs of the Shuttle program, as we now see it.

General CURTIN. That is the way it was cast. That is correct, sir.

Mr. TALCOTT. Are we together with the Air Force on this and the authorizing committees?

General CURTIN. Yes; I believe so.

As far as the Air Force is concerned, the answer is yes, without any reservation. The authorizing committees did raise further questions during our hearings this year as to the expandability of the hangar, the point that you brought up. I cannot say whether or not they are completely satisfied with the responses.

NEED FOR FRC HANGAR

Mr. TALCOTT. There was some question whether this hangar was needed when you had such a good facility at Edwards just a short distance away. Do you have any better explanation for that?

It appears to be a duplication to some people.

General CURTIN. It is not a duplication. All the facilities at Edwards, both NASA and Air Force, have been screened on several occasions to see if they could be made available and otherwise used for the Shuttle programs without any success. It was only as a last resort that this FRC hangar was programed last year.

As you realize, there was a change in requirements and concept that required us to come back for additional money. That took place subsequent to the fiscal year 1975 budget submission.

Dr. LOW. As I understand it, the authorizing committees last year wanted us to build a bigger facility to use for the Shuttle and for long-range aeronautics needs. We are building the minimum facilities required for the Shuttle, with the understanding that if the aeronautics program should be expanded in the future, we will come in for further appropriations to expand that facility. It can be expanded in length but not in width.

Mr. LILLY. This plan is consistent with NASA's current projections in terms of the use of aircraft. We are not expecting any large increase in the use of wide-wing aircraft. So it is capable, I believe, of being fully utilized to support the aeronautics program after its use for the Shuttle.

PALMDALE AND FRC FACILITIES NOT INTERCHANGEABLE

Mr. TALCOTT. But the work being done at Palmdale and the work being done at the Flight Research Center are simply not interchangeable?

Mr. LILLY. That is correct, Mr. Talcott, they are not interchangeable. One of the questions raised by Senator Proxmire as to the facilities at FRC was whether or not we could tow the orbiter, since the locations are only about 50-miles apart, from Palmdale to the Flight Research Center.

Mr. TALCOTT. On land?

Mr. LILLY. On land. Complete studies were done on this, prior to our decision, in terms of every obstacle—every tree and telephone post that would have to be moved and the overpasses involved. My recollection is that it was $2 to $3 million more expensive, even for a one-time operation, without even replacing the trees.

Mr. TALCOTT. This question of the FRC hangar is a controversy that caused some misunderstanding on the floor last year. I think it is important. Are there any other facilities of this nature in the Palmdale-Edwards area that could be used other than building this new hangar?

Mr. LILLY. No, sir. We looked at all the facilities at Edwards, at both the north and south base facilities. None of these facilities were capable of handling the requirement.

Mr. TALCOTT. Thank you. I will ask more questions later.

Mr. TRAXLER. Mr. Young.

ASSEMBLY AND CHECKOUT FACILITIES AT PALMDALE

Mr. YOUNG. The facility at Palmdale is larger for the purpose of assembly. You are going to assemble parts shipped in. Who will do this assembly?

Is this a NASA team or Air Force or will you have a contractor performing the assembly function?

Dr. LOW. It is Rockwell International, the prime contractor on the Space Shuttle Orbiter, under NASA supervision.

ORBITER/747 CARRIER AIRCRAFT OPERATIONS

Mr. TALCOTT. Who checks out 747 pilots who are going to fly the carrier or the Orbiter?

Dr. LOW. The effort will be under the control of both our Johnson Space Center, Houston, and our Flight Research Center at Edwards. Both have specific parts of the responsibility for the approach and landing tests.

Mr. TALCOTT. Are they pilots you recruit from United Airlines or are they from the Air Force?

Dr. LOW. They are our own test pilots.

Mr. TALCOTT. You have pilots who are qualified to fly 747's?

Dr. LOW. Yes, Mr. Talcott. We have some of the best pilots in the world. I have flown with some of them. I think they are without any doubt the best engineering test pilots in the world because they have experience with so many different types of aircraft. They are highly professional.

Mr. TALCOTT. On the first flight where you take the Shuttle along, who will fly? What is the crew on that? Will there be people like you flying on it?

Dr. LOW. No, although I would love to do it.

Mr. TALCOTT. How about Dr. Schmitt?

Dr. FLETCHER. These would be experienced test pilots. Some of our astronauts are former test pilots, so we would not exclude them from the operation. But the chances are we would use the Flight Research Center's own test pilots.

Dr. LOW. The FRC test pilots would probably be in the 747 and astronauts would be in the Shuttle Orbiter for the approach and landing tests.

SAFETY OF CARRIER AIRCRAFT OPERATIONS

Mr. TALCOTT. This is going to cause a lot of attention around the world. We are all going to be concerned about the safety of the people. It is not known that some of these test pilots take a tremendous risk and generally do not get much credit for it. This will cause a lot of international attention, I imagine. So we have to be concerned about the crew that is going to be doing it, their safety and who goes along and how necessary they are to the mission.

Dr. LOW. I can assure you that the only people who will go along will be the flight crew—pilots, navigators, and engineers who are necessary to perform that test. We have taken a strict approach on that in all our test flying.

Mr. YOUNG. In other words, he just rejected my request of Tuesday.

Dr. SCHMITT. He rejected my application, too.

CONSTRUCTION OF SHUTTLE/CARRIER AIRCRAFT MATING FACILITIES

Mr. TRAXLER. On page CF 4–44, is the request for construction of Shuttle/carrier aircraft mating facilities. Once you decided to go with the piggy-back operation, transporting the Shuttle on the back of the 747, obviously these facilities were required. You reprogramed about $4 million last year to get this started. Now you are asking for $3,890,000 additional to complete that specific work?

General CURTIN. That is correct, Mr. Chairman.

Mr. TRAXLER. How many mating devices do you think will be constructed?

General CURTIN. There are two involved: one at Palmdale and one at the Flight Research Center. A third will be required at the Kennedy Space Center launch site and will be requested in a future C. of F. program.

Mr. TRAXLER. Do you feel that will be the total number of mating devices?

General CURTIN. That is how we see it at the present time.

Mr. Yardley may want to add to my comment.

Mr. YARDLEY. There will be another mating device required at Vandenberg, but we want to see if we cannot work it so that we can get by with just three. We have been looking at using large hoists on a one-time basis at the Marshall Space Flight Center. Based on our current plan, Orbiter No. 1 will be taken to the Marshall Space Flight Center for vibration tests after the approach and landing test program is completed. At that point, we will make sure that we can use the portable hoist arrangement. After that, we may use the concept for the Palmdale operation, and possibly release the mating-demating unit for use at Vandenberg downstream in the program.

MODIFICATIONS FOR SOLID ROCKET BOOSTER COMPONENT MANUFACTURING AND ASSEMBLY FACILITIES

Mr. TRAXLER. Thank you.

On page CF 4–59, there is a request for $3 million for modifications for solid rocket booster component manufacturing and assembly facilities. I presume this is not the same item deleted by the authorization committees last year.

General CURTIN. No, sir, this is a new item. This is for solid rocket booster component manufacturing and assembly facilities, as opposed to the rockets themselves.

REPROGRAMING NOTIFICATION PENDING

Mr. TRAXLER. Last year you felt there would definitely be money required to some extent for the project that was deleted.

General CURTIN. That is correct.

Mr. TRAXLER. We notice that you did not come back and ask for it, though.

Mr. LILLY. I wanted to mention the status on this. It is undoubtedly true, as much as we had hoped it would not be necessary, that we are going to have to transmit a proposed reprograming action to you within the next 2 to 3 weeks. We had hoped there would be a possibility that Thiokol would acquire that plant, but this is not being consummated.

According to the Government rules and the Cost Accounting Board, it appears that the Government will have to spend the money for the permanent capitalization items in this plant. We hope that we will be able to do this for about $1.5 or $1.6 million. We have not yet reviewed the requirements in detail with Dr. Fletcher or Dr. Low.

Dr. FLETCHER. In all fairness, Mr. Chairman, at the time that we submitted the budget to the Congress, we really had not been involved in detailed negotiations; we had no idea that we could not do without the facility. It is only in recent weeks that we have become fully aware of the need.

Mr. LILLY. One of the problems during that period, as you recall, was that the award of the solid rocket motor contract to Thiokol was under protest and was being reviewed by the GAO. The GAO rendered their report shortly after the Appropriations Committee had acted and had deleted the item. We were prohibited, in a sense, from going in and doing detailed studies of the Thiokol facilities during this period of the protest. That is one of the reasons why we could not conduct a detailed review earlier.

Mr. TRAXLER. Do you anticipate that you are going to have any other requests in your reprograming action of 2 to 3 weeks from now?

Mr. LILLY. No, sir. That is the only one I am aware of now. If there are other items, they would be problems that we are certainly not aware of at this point.

AMES MODIFICATION OF TRANSONIC WIND TUNNEL

Mr. TRAXLER. Turning to page CF 1–2, $2,695,000 is requested for modification of the 11-by-11-foot transonic wind tunnel at the Ames Research Center. Last year we had a lengthy discussion of wind tunnel requirements. You indicated that NASA and DOD would jointly fund four wind tunnels. Is this one of those four tunnels?

General CURTIN. No, Mr. Chairman, it is not. I believe at that time we were talking about the large aeronautical facilities.

AERONAUTICAL FACILITIES

Mr. TRAXLER. Can you talk with us for a moment about those four large aeronautical facilities and tell us what is happening with them?

Dr. LOVELACE. We are still finalizing our discussions with DOD and, more specifically, the Department of the Air Force, with regard to the four large aeronautical facilities. Those facilities are the 40-by-80 wind tunnel, repowering and raising the speed range of that tunnel, which is the largest wind tunnel in the free world; the transonic wind tunnel, originally proposed for Langley, and a companion engineering facility for the Air Force called the high Reynolds number test facilities contemplated for the Arnold Engineering Development Center facility; and another Air Force facility, an engine test facility, also for that same installation.

Those basic requirements still remain firm today. In conjunction with the Air Force, we have been looking at two concepts for obtaining the combined test capability, the transonic capability, at Langley, and the high Reynolds facility capability at the Arnold Engineering facility. We anticipate that these discussions will be completed very shortly and that we will have converged on a candidate for a single facility that will meet the research and development requirements of both NASA and the Air Force.

We will be prepared at that time to come back and discuss with the Congress those requirements.

NEED FOR MODIFICATION OF 11-BY-11-FOOT TRANSFER

Mr. TRAXLER. You are contemplating modifications to the 40-by-80-foot wind tunnel, and you are requesting funds to modify the 11-by-11. Why do you need the 11-by-11-foot wind tunnel?

Dr. LOVELACE. The 11-by-11-foot tunnel modifications requested in the fiscal year 1976 budget is one of the basic higher speed, smaller throat diameter facilities. That is what the 11 feet by 11 feet refers to. The 40-by-80 is a slower speed tunnel but larger, capable of handling smaller aircraft, full-size aircraft in the throat section.

Dr. LOW. Wind tunnels are one of the basic tools of the aeronautical engineer. It would be ideal if it were possible to build one wind tunnel that could simulate the total flight regime from landing and takeoff speeds to supersonic speeds, but it is physically impossible to design a tool like that. Therefore, we have a substantial number of wind tunnels between ourselves and the Air Force that cover different parts of the speed range and different parts of the altitude range. We simulate in wind tunnels. We can duplicate only small parts of the flight regime in one wind tunnel. Therefore, there are large numbers of wind tunnels around the country. This 11-by-11 foot tunnel is one of the older ones covering a certain speed range. We are requesting necessary funds to modify that tunnel.

WIND TUNNEL REQUIREMENTS

Mr. BAUCUS. How many different ranges do you need?

Dr. LOVELACE. We break it down into subsonic, transonic, supersonic, and hypersonic. Subsonic is below the speed of sound, below

700 miles an hour. Supersonic covers from the speed of sound to about 3½ times the speed of sound. Transonic covers a range from eight-tenths to nine-tenths the speed of sound to about 1.2 the speed of sound. That is the most difficult range to design a tunnel for because all sorts of interference occur in the tunnel and bounce back on the models. So transonic tunnels are the most difficult.

I have covered up to a speed of 3½ times the speed of sound. Hypersonic then takes off beyond 3½ times the speed of sound where we are doing some very basic research. In addition to that, we have various sizes of test sections within our tunnel complex. It is economical to test in as small a tunnel as possible because you need less equipment, less airflow, smaller pumps, et cetera.

Sometimes you have to test airplanes in a facility that approaches the full scale of the airplane, or comes as close as possible, to get the best simulation.

We do most at small scale, but we have a few that go to larger scale. Speed is one factor and size is another. The third is altitude. The Reynolds number is related to the pressure at altitude.

We need to test at various levels of that number. As a result, you have to build a matrix in several cuts. In NASA, we have 40 major wind tunnels busy all the time.

Mr. BAUCUS. In your various speed ranges, can you mix in altitude?

Dr. LOVELACE. Yes.

COORDINATION OF WIND TUNNEL REQUIREMENTS

Mr. BAUCUS. So you don't need a supersonic high altitude facility separate from a supersonic low altitude one; you can mix those two together?

Dr. LOVELACE. The various supersonic tunnels do cover different altitude ranges. Yes; you do need some for low altitude and some for high altitude.

Mr. BAUCUS. Obviously, some of this is a question of judgment. There is some overlap. I am wondering how closely you have looked at the cost effectiveness of this construction compared to where overlap might occur.

Dr. LOVELACE. First of all, we have closed a large number of facilities in the past several years. We review the requirements constantly to see if some of the existing facilities can be converted or closed.

I have a list here of nine wind tunnels that we have taken out of service; three more which were converted; and six which are used only part time now. We look continually at what we really need and we conduct these reviews to assure that we have optimum efficiency in terms of manpower and use.

In addition, we also, of course, coordinate with the Air Force, the DOD, to make sure that we achieve the best possible use of all the available facilities.

Mr. BAUCUS. Thank you.

SHUTTLE/CARRIER AIRCRAFT MATING FACILITIES

Mr. TALCOTT. May I ask something about the mating and demating? As I understand it, the assembly of the orbiter will be at Palmdale so

we need one of these mating and demating facilities. That is a large thing. Will it be outdoors?

Dr. Low. The mating facilities will be outdoors. It has to be large enough so that the orbiter can be lifted on top of the 747 carrier aircraft. Since both are large, it takes a large facility to take care of the mating-demating requirements.

Mr. TALCOTT. It is relocatable, but what can relocate it?

Dr. Low. It can be taken apart, like an erector set, and moved.

Mr. TALCOTT. So it can be moved from Palmdale to Edwards?

General CURTIN. That is right. About 90 percent of the investment is salvageable. You would abandon something like $200,000 to $250,000 in the ground.

Mr. TALCOTT. It will be used at Palmdale. When the orbiter is flown you might get a separation and might not. The 747 might have to land with the orbiter still on top.

Dr. Low. That is correct, Mr. Talcott.

COST OF MATING DEVICE

Mr. TALCOTT. So you will need this mating and demating facility. How much does this huge crane cost?

General CURTIN. The mating device itself is about $2.3 to $2.5 million.

Mr. TALCOTT. Apiece?

General CURTIN. Yes, sir.

Mr. TALCOTT. You will also need one at Kennedy and one at Edwards and perhaps one at Vandenberg?

Dr. Low. Yes, those are the three that Mr. Yardley mentioned.

Mr. TALCOTT. It appears that you might need four.

Dr. Low. There is a possibility that ultimately we will need four. As. Mr. Yardley mentioned, we are hopeful that for the very occasional use, for example, when we take orbiters back to Palmdale after we have relocated that facility, if we take them back to refurbish them, we will make do with large cranes or hoists, We know we cannot make do with hoists for the periodic use because it is more dangerous as far as the vehicles are concerned and will take much more time.

FUTURE MATING FACILITIES REQUIREMENTS

Mr. TALCOTT. Will there be any other use for this facility?

General CURTIN. Provisions will also be made for the capability to make external tanks to the 747 aircraft for transportation from assembly sites to launch sites. In the event that additional facilities for this capability should be required, they could then be added in a future C. of F. program.

Dr. Low. We may also carry the large external tank, which is part of the Shuttle system, piggyback on the 747. If we do, the same facility, with minor modifications, could be used.

Mr. YOUNG. Is the gear on the 747 adequate to handle landing with the orbiter on its back?

Dr. Low. The orbiter provides a little lift so that the landing loads are somewhat less with the orbiter on its back.

Mr. YOUNG. I assume the 747 would be stripped so its payload there would be comparable to that of the commercial 747—it would be without people or luggage or seats, but with the orbiter on its back.

Dr. LOW. Yes.

JSC—ADDITION TO LUNAR SAMPLE CURATORIAL FACILITY

Mr. TRAXLER. Let's turn to the Johnson Space Center. On page CF 2–2, you are requesting $2,490,000 for an addition to the existing lunar curatorial facility. What is the Lunar Receiving Lab being used for?

General CURTIN. The Lunar Receiving Lab is gradually being converted to house the consolidated life science facilities at the Johnson Space Center.

NEED FOR ADDITION TO CURATORIAL FACILITY

Mr. TRAXLER. Had you considered using the receiving lab for storing the lunar material?

General CURTIN. It has been considered. There were two factors involved: one was the timing of its availability prior to the need for having the present facilities in being; and second, the overall cost. The timing was not satisfactory, and the overall cost would have been greater.

Mr. TRAXLER. Do you have some existing space at the Johnson facility with the winding down of the manned flights that you could convert for this purpose?

General CURTIN. No, sir. It is not that we could not convert. There are existing small pockets of space throughout the Center as we have been adjusting utilization between Johnson and Ellington Air Force Base and trying to get as many people back on the Center as possible. However, there is no space that could be adapted for this purpose at a lower cost.

REHABILITATION AND MODIFICATION OF FACILITIES

Mr. TRAXLER. Turning to page CF 5, the rehabilitation and modification of facilities. Each year NASA requests approximately $14 to $16 million to rehabilitate the facilities at NASA Centers and various locations. Last year you indicated that this was a long range program that would cost somewhere in the area of $200 million. How much do you anticipate will be completed with the fiscal year 1976 increment and the transition period funds?

General CURTIN. First, I would like to give you an update on our backlog, if I may, Mr. Chairman.

Our current backlog is about $160 to $170 million. That is our updated figure on backlog that we have identified to date. Through fiscal year 1975, there has been approximately $78 million budgeted for this purpose, to which you would have to add the $16 million in the fiscal year 1976 program and the $8.75 million in the transition period, which would bring it slightly over $100 million. So we are somewhere in the 40-percent range of the backlog, as we have now identified it.

ANTICIPATED FISCAL YEAR 1977 REHAB AND MOD PROGRAM

Mr. TRAXLER. I notice that about $8.7 million requested for the transition period annualizes out to about $35 million. What is your anticipated fiscal year 1977 request for this program?

General CURTIN. The fiscal year 1977 request, as we see it now, will be on the order of $15 million to $20 million. There may be some adjustment, however, as we make the final budget decisions. If I may, I would like to comment on the selection process.

We have been trying to get on with reducing this backlog as rapidly as possible, basically because of the same considerations that the committee discussed yesterday. These are things that have to be done to protect our investment. The sooner we can do them, the more economical and the sooner we will be able to take advantage of the end product.

As a result we have not been looking at this program so much as a level of effort program as a program developed in terms of projects that should be done in a given time frame.

Through the transition period, we identified work that, as prudent managers, we feel must be done in that timeframe, instead of looking at it as an annual program level of effort.

Mr. TRAXLER. I have no further questions. Do any members have any questions?

Thank you, gentlemen.

Mr. Baucus.

RESEARCH AND PROGRAM MANAGEMENT

Mr. BAUCUS. We will turn to "Research and program management." Place pages SUM 1 through SA 18 in the record at this point. We will refer to the appropriate pages as we proceed through the Research and Program Management budget justifications.

[The paper follows:]

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1976 ESTIMATES

GENERAL STATEMENT

The Research and Program Management appropriation funds research in Government laboratories, management of programs, and other agency activities. Principally, this appropriation provides for (1) the civil service staff needed to perform in-house research, and to plan, manage, and support the Research and Development programs; and (2) the other elements of operational capability of the laboratories and facilities such as utilities, logistics support (travel and transportation, maintenance, and operation of facilities), and technical and administrative support.

The in-house personnel funded by the Research and Program Management appropriation are engaged in research and technology, and direct and indirect support of project work. Over three-fourths of this appropriation is required to cover salaries and related costs of these employees. The balance, consisting of travel, facilities services, technical services, and administrative support of all NASA installations, provides the test and operational facilities support and related goods and services which make possible the efficient accomplishment of NASA's approved missions.

Management of Installations

The future of our aeronautics and space activities depends on the strength of our most important resource -- the approximately 24,000 people located at our various centers and installations. We intend to keep this resource viable and young in spirit, second to none in science, research, development and technology. To improve the overall effectiveness and economy of centers' operations, in March 1974 management of field operations was assigned to the Associate Administrator for Center Operations. Thus, responsibility was consolidated for overall planning and direction of NASA's field center operations in one senior line official.

In addition to this change, the National Space Technology Laboratories (NSTL), which was formerly a component facility of the Marshall Space Flight Center, was created as a separate NASA facility. This action was taken to recognize the diverse, multiprogram character of activities carried on there by several Federal agencies, and to provide the necessary focus on support to these diverse activities.

Summary of Changes - 1975

Since NASA's preparation of the 1975 budget and subsequent to final action by the Congress, several significant events have occurred that bear on the current operating budget.

The amount appropriated for Research and Program Management (R&PM) was $740,000,000, a reduction of $9,624,000 from the budget request. Congress also provided appropriation transfer authority to allow NASA to properly balance the R&D and R&PM efforts. Under this authority R&PM funds have been increased by $5,200,000 to provide the minimum funding level necessary to support adequately the approved research and development programs and projects. As a result of the transfer from R&D, the budget plan is increased to $745,200,000. Including the anticipated supplemental appropriation to cover the October 1974 pay raise, the operating budget for 1975 is $765,175,000.

In September 1974, as an element of his actions against inflation, the President directed a Government-wide reduction in manpower. NASA's share of that reduction was 300 positions. This reduction is being taken through normal attrition at all centers except Marshall Space Flight Center, where a reduction in force had already been planned. It is estimated that the savings resulting from this 300-man reduction will be approximately $425,000 in 1975.

A general pay raise of 5.5% was implemented by Executive Order in October 1974. The estimated additional 1975 cost of the revised salary rates is $19,975,000, for which no provision was made in the Agency's 1975 budget request. A supplemental appropriation has been requested to cover these costs.

Section 205 of the Supplemental Appropriation Act, 1975, P.L. 93-554, limits Federal travel expenses. The effect of this legislation is to reduce travel by 5% from the 1975 budget estimate. This reduction amounts to $822,000, resulting in an operating budget for 1975 of $15,622,000 for travel.

The operating budget, therefore, includes the net effect of Executive and Legislative actions on increased salaries, and reductions in personnel and travel. The operating budget also includes absorption of other unbudgeted requirements such as increases in utility rates, airline fares, support contract wage rates and prices of supplies, materials, and equipment.

Summary of Changes - FY 1976

The budget for 1976 is $776,000,000, an increase of $10,825,000 over the revised plan for 1975. The 1976 estimate provides for the full year effect of increased utility rates which continue to rise more rapidly than conservation efforts can offset. Additionally, continued increases in wage rates as well as in the cost of materials are provided for. Personnel compensation estimates include the net cost of the full year effect of the October 1974 pay raise, offset by the full year effect of the 1975 300-position reduction.

SUMMARY OF 1975 CURRENT ESTIMATE
AND 1976 ESTIMATE

	1975 Current Estimate	1976 Estimate
Budget request	$749,624	
Congressional action	-9,624	
Appropriation	740,000	
Appropriation transfer for minimum requirements	+5,200	
Plan, prior to October 1974 pay raise	745,200	$748,000
Effect of October 1974 salary rates	+19,975	+28,000
Plan, based on October 1974 salary rates	$765,175	$776,000
Proposed supplemental appropriation to cover FY 1975 deficiency	$19,975	

Transition Period Budget

The budget request for the transition period provides for continuation of acitivities at the FY 1976 level.

Summary of Obligations by Function

The table below summarizes requirements by functional category:

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)				
Personnel and related costs	$573,182	$579,065	$591,915	$597,513	$156,759
Travel	15,507	16,444	15,622	17,001	5,065
Facilities services	74,822	79,349	83,087	85,590	28,850
Technical services	36,712	34,261	32,846	33,871	10,230
Administrative support	43,745	40,505	41,705	42,025	12,896
Total	$743,968	$749,624	$765,175	$776,000	$213,800

The Research and Program Management appropriation request may be categorized into five functional areas as follows:

1. Personnel and Related Costs includes salaries and benefits for civil service personnel, and for personnel of other government agencies detailed to NASA. This category also includes supporting personnel costs, such as the costs of moving expenses (excluding travel of personnel), recruiting and personnel investigation services provided by the Civil Service Commission, and personnel training. The major factor contributing to the increase in the 1975 current estimate over the 1975 budget estimate is the October 1974 pay raise cost of $19,975,000.

The 1976 increase results from the annualization of the October 1974 pay raise as well as the costs for statutory within-grade increments and career promotions. This is partially offset by annualized savings from the reduction of 300 positions in FY 1975.

2. Travel includes the cost of transportation, per diem, and other associated expenses required for direction, coordination, and management of research and development and construction of facilities program activities; for contract management and flight mission support; for overseas travel to launch and tracking sites; for travel to meetings and technical seminars; and for all local and relocation travel expenses. The 1975 current estimate is $822,000 less than the 1975 budget estimate. This results from the Government-wide reduction required by the Supplemental Appropriation Act, 1975. The net effect of this amendment is to reduce travel costs by 5% from the 1975 budget estimate. Travel requirements for 1976 are estimated at the 1975 level, adjusted to take into account increased air fares.

3. Facilities Services includes rental of real property, the cost of maintenance and related services, custodial services, minor modifications, utilities and facility operations. The increase in the 1975 current estimate as well as in the 1976 estimate is primarily attributable to wage escalation, utility rate increases and higher supplies and materials costs.

3. Technical Services includes the cost of general purpose automatic data processing, institutional engineering services, the dissemination of scientific and technical information derived from the various research and development programs, and educational/informational program activities. The reduction from the 1975 budget estimate to the current estimate is the result of deferring planned equipment acquisitions to provide for unavoidable wage and price escalation. The FY 1976 level of effort is planned at the 1975 level; however, wage rate increases on existing contracts will raise costs for 1976.

5. Administrative Support includes the cost of communications, administrative printing, administrative supplies, general purpose materials and equipment, transportation support (excluding movement of personnel), and other support activities. The 1975 current estimate is greater than the

budget estimate because of higher prices for supplies and materials and communications rate increases. The increases planned for 1976 reflect full year costs of communciations rate and contractor wage increases.

The content of these functions is explained in mare detail in the following pages. The detailed requirements for each installation are covered in their respective sections of this presentation.

PERSONNEL AND RELATED COSTS

A. COMPENSATION AND BENEFITS

1. Compensation

a. Permanent Positions: This category of personnel costs covers the salaries of permanent civil service employees, and is the largest part of personnel and related costs. The funds shown will support the civil service complement of 24,316 at the end of FY 1975 and FY 1976. The estimate for permanent compensation is based upon the position structure at the start of the year, as modified by the addition of new positions, within grade advances, career development, etc.

b. Nonpermanent Positions: The nonpermanent position category covers the salaries of nonpermanent employees participating in the College Cooperative Training, Summer Employment, Youth Opportunity and Temporary Clerical programs.

The College Cooperative Training program provides alternating work and study periods providing the student with practical experience and academic training. This program permits many students to attend college who could otherwise not afford to by providing them an income during their work period. This program has been a principal source of recruitment for young and experienced professional personnel.

The Summer Employment program employs high school and college students and faculity members, and in consonance with the Federal Government policies and objectives provides them an insight into government operations. The agency benefits from the employment of these highly skilled and motivated individuals.

The Youth Opportunity Campaign program is conducted within the national policy which enables disadvantaged youths to work at unskilled jobs both during the summer and throughout the regular school year.

The Temporary Clerical program is necessary to provide short-term support in positions occupied by permanent employees who are absent from work because of illness, vacation, maternity, or training.

c. Reimbursable Details: In accordance with existing agreements, NASA reimburses the parent Federal organization for the salaries and related costs of the detailees to NASA.

d. Overtime and Other Compensation: Overtime, holiday pay, post and night work differential, and hazardous duty pay are paid from 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, employee life and health insurance, and social security contributions for nonpermanent employees. The incentive awards provide cash awards for outstanding achievements by NASA employees, superior performance awards and for improvements of a center's operations. Payments for severence 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 of household goods are provided under this category.

2. Civil Service Commission Services

The Civil Service Commission is reimbursed for security investigations on new hires for the entire agency, for recruitment adversiting, 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 training consists of courses offered by other Government agencies, usually for a fee, and the remainder is provided through nongovernment sources.

TRAVEL

A. Program Travel

The largest individual part of program travel is for direction, coordination and management of program activities. Because of the programs and the geographical distribution of NASA centers and contractor and subcontractor effort throughtout the entire United States, coordination and management of activities require frequent review by prosonnel with program responsibility.

As projects reach the flight stage, support is required for prelaunch and postlaunch 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. Administrative Travel

Administrative travel includes travel for the direction and coordination of general management matters and travel by senior officals to review requirements and operations. 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; initial duty station, permanent change of assignment, and other family travel expenses; local transportation; rental of passenger-carrying motor vehicles; and travel of non-NASA employees.

C. Meetings and Technical Seminars

Travel to meeting and technical seminars permits employees engaged in program activities to participate at both government-sponsored and non-government-sponsored meetings and seminars with other representatives of the aerospace community. This participation allows personnel to benefit from exposure to 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 made up of working panels convened to solve certain problems for the benefit of the government.

FACILITIES SERVICES

A. Rental of Real Property

This category covers costs for rental of land and property to house personnel and provide storage and warehouse space for equipment, supplies, and materials where space is not available in government-owned facilities; and as a new requirement effective July 1, 1974, reimbursement to GSA for governement-owned or leased space including office buildings in Washington D.C., under the control of and provided by GSA.

B. Maintenance and Related Services

1. Maintenance, Repair and Alteration of Buildings and Grounds

This category includes general building maintenance, painting of structures, general ground maintenance, and maintenance of utility systems. This activity also provides for minor alterations of facilities.

2. Custodial Services

This category includes janitorial, laundry, guard and security, fire protection, and refuse handling services.

3. Maintenance of Equipment

Maintenance of equipment consists of work necessary to keep mechanical, electrical, general purpose, and shop equipment operations.

C. Operation of Facilities

1. Utilities

This category reflects the cost of electricity, water, gas and other utilities for all areas, both institutional and operational.

2. Supplies and Equipment

This category includes the supplies, materials, and equipment required for the maintenance and operation of facilities at each installation.

TECHNICAL SERVICES

A. Automatic Data Processing

1. 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 operationsl systems which is funded from the Research and Development appropriation.

2. Programming and Operation Services

Programming and operation services include system analysis, programming, computer operation and related services. Business-type applications include payroll, personnel data, logistics, and procurement records and reports.

B. Scientific and Technical Information and Educational Programs

These programs include the costs of the technical libraries, educational/informational programs, and the scientific and technical information services.

1. Operation of Technical Libraries

The technical library was established to service employees with their information needs for books, periodicals, technical reports, and other documentation. The costs for these services are budgeted in this subfunction.

2. Educational/Informational Programs

The educational/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.

3. Scientific and Technical Information

Scientific and technical information activities include documentation, publication, photographic and translation services.

C. Engineering Services

The engineering services provide for reliability and quality assurance studies, engineering design services for the design of minor construction, repair and alteration projects; special tooling equipment and machine parts; and other related engineering services.

ADMINISTRATIVE SUPPORT

A. Communications

Included in this category are costs of leased lines, long distance tolls, teletype services, local telephone service and other communications.

B. Administrative Printing

Included in this category are costs for duplicating, blueprinting, microfilming, and other photographic reproductions. Also included in this category is contractual printing and the related composition and binding operations, whether performed by other agencies (chiefly the Government Printing Office), or by commerical printing firms.

C. Supplies, Materials and Equipment

This category includes administrative supplies, materials, and equipment.

D. Transportation

Transportation services include rental of vehicles utilized for transportation of cargo. The cost of aircraft operations and services, as well as the movement of all supplies, materials, equipment, and related items by common carrier is also included.

E. Administrative Support Services

Administrative support services include those activities which support each installation such as: mail and distribution services; maintenance and repair of office equipment and vehicles; occupational medicine and environmental health; patent services; operation of photocopy equipment; claims of property damage; chart and related art work. Various improvement and feasibility studies and related services are also included in this category.

DISTRIBUTION OF PERMANENT POSITIONS BY INSTALLATION

Installation	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
Johnson Space Center.....	3,652	3,652	3,613	3,613	3,613
Kennedy Space Center.....	2,309	2,309	2,259	2,259	2,259
Marshall Space Flight Center.....	4,500	4,145	4,113	4,113	4,113
National Space Technology Laboratories.....	65	65	70	70	70
Goddard Space Flight Center.....	3,808	3,808	3,754	3,754	3,754
Wallops Flight Center....	420	420	415	415	415
Ames Research Center.....	1,701	1,700	1,676	~~1,676~~	1,~~676~~
Flight Research Center...	484	483	489	489	489
Langley Research Center..	3,375	3,371	3,332	3,332	3,332
Lewis Research Center....	3,115	3,072	3,025	3,025	3,025
Headquarters.....	1,591	1,591	1,570	1,570	1,570
Total, Permanent Positions.....	25,020	24,616	24,316	24,316	24,316

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1976 ESTIMATES

RESEARCH AND PROGRAM MANAGEMENT

SUMMARY OF OBLIGATIONS BY INSTALLATION
(Thousands of Dollars)

Installation	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
Johnson Space Center.....	117,936	118,179	121,612	125,196	34,966
Kennedy Space Center.....	93,555	96,739	95,896	94,974	29,753
Marshall Space Flight Center.....	136,644	129,718	131,316	130,506	34,372
National Space Technology Laboratories.....	1,556	1,497	1,673	1,696	423
Goddard Space Flight Center.....	97,481	100,579	104,833	105,847	27,740
Wallops Flight Center....	11,488	11,704	12,100	12,705	3,543
Ames Research Center.....	46,424	47,956	48,335	49,257	12,749
Flight Research Center...	12,239	12,492	13,173	13,714	4,907
Langley Research Center..	83,759	84,989	88,104	90,710	23,387
Lewis Research Center....	79,858	78,438	79,921	81,902	21,936
Headquarters.....	63,028	67,333	68,212	69,493	20,024
Total.....	743,968	749,624	765,175	776,000	213,800

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1976 ESTIMATES

RESEARCH AND PROGRAM MANAGEMENT

DISTRIBUTION OF PERMANENT POSITIONS BY PROGRAM

Program Office and Program	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
MANNED SPACE FLIGHT.....	7,391	7,275	7,123	7,117	7,117
Space shuttle.....	3,739	3,974	4,097	5,172	5,172
Space flight operations....	3,598	3,234	2,969	1,878	1,878
Advanced missions.....	49	56	55	67	67
Apollo.....	5	11	2	---	---
SPACE SCIENCE.....	3,016	3,196	3,034	2,915	2,915
Physics and astronomy.....	1,733	1,823	1,743	1,648	1,648
Lunar and planetary.....	659	709	635	558	558
Launch vehicle procurement.	624	664	656	709	709
SPACE APPLICATIONS.....	1,694	1,673	1,682	1,694	1,694
AERONAUTICS AND SPACE TECHNOLOGY.....	5,463	5,602	5,302	5,411	5,411
Aeronautical research and technology.....	3,861	3,899	3,786	3,849	3,849
Space and nuclear research and technology.....	1,602	1,703	1,516	1,562	1,562
ENERGY TECHNOLOGY APPLICATION	140	---*	254	241	241
TRACKING AND DATA ACQUISITION.....	857	821	858	878	878
TECHNOLOGY UTILIZATION.....	77	78	72	69	69
Subtotal, Direct Positions.....	18,638	18,645	18,325	18,325	18,325
Indirect Positions.....	6,382	5,971	5,991	5,991	5,991
TOTAL, PERMANENT POSITIONS...	25,020	24,616	24,316	24,316	24,316

*FY 1975 Budget Estimate included energy application positions in space and nuclear research and technology and Space Applications.

SUM 12

51-423 O - 75 - 43

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1976 ESTIMATES
RESEARCH AND PROGRAM MANAGEMENT
DISTRIBUTION OF OBLIGATIONS 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	Flight Research Center	Langley Research Center	Lewis Research Center	Headquarters
Personnel and Related Costs												
1974.....	573,182	87,796	51,749	111,632	1,532	81,990	7,784	37,632	10,061	69,967	69,584	43,455
1975 Budget...	579,065	88,992	54,291	106,029	1,474	84,178	8,037	39,497	10,454	72,601	69,598	43,914
1975 Current..	591,915	93,138	53,717	107,439	1,650	87,099	8,278	39,742	11,107	74,698	70,039	45,008
1976.....	597,513	94,231	54,242	105,900	1,672	87,630	8,527	40,315	11,346	76,036	71,833	45,781
Transition....	156,759	24,268	14,587	27,150	418	22,861	2,197	10,363	3,003	19,494	18,735	13,683
Travel												
1974.....	15,507	2,925	1,625	1,916	24	2,249	234	889	246	1,903	1,063	2,433
1975 Budget...	16,444	3,498	1,456	2,233	23	2,245	265	899	235	1,910	1,065	2,615
1975 Current..	15,622	3,232	1,582	1,962	23	2,274	237	815	224	1,980	994	2,299
1976.....	17,001	3,666	1,764	2,115	24	2,255	251	878	242	2,267	1,074	2,465
Transition....	5,065	1,015	664	556	5	631	123	289	84	681	316	701
Facilities Services												
1974.....	74,822	11,192	25,179	9,215	---	5,839	2,651	4,625	1,391	6,345	7,938	447
1975 Budget...	79,349	11,423	25,972	8,974	---	7,421	2,413	5,247	1,364	5,895	6,400	4,240
1975 Current..	83,087	12,290	25,452	9,415	---	8,460	2,654	5,345	1,426	6,421	7,587	4,037
1976.....	85,590	13,110	24,488	9,601	---	9,194	2,920	5,618	1,609	7,172	7,773	4,105
Transition....	28,850	4,964	8,961	3,143	---	2,474	877	1,403	1,500	1,890	2,538	1,100

Technical Services												
1974.....	36,712	7,199	6,462	6,722	---	2,445	193	671	81	1,549	356	11,034
1975 Budget...	34,261	6,048	6,167	6,884	---	1,882	227	675	91	1,208	432	10,647
1975 Current..	32,846	5,986	5,487	6,701	---	1,791	248	626	79	1,171	486	10,271
1976.....	33,871	6,707	5,180	6,919	---	1,914	274	632	76	1,202	406	10,561
Transition....	10,230	2,156	2,190	1,870	---	508	17	127	52	380	144	2,786
Administrative Support												
1974.....	43,745	8,824	8,540	7,159	---	4,958	626	2,607	460	3,995	917	5,659
1975 Budget...	40,505	8,218	8,853	5,598	---	4,853	762	1,638	348	3,375	943	5,917
1975 Current..	41,705	6,966	9,658	5,799	---	5,209	683	1,807	337	3,834	815	6,597
1976.....	42,025	7,482	9,300	5,971	---	4,854	733	1,814	441	4,033	816	6,581
Transition....	12,896	2,563	3,351	1,653	---	1,266	329	567	268	942	203	1,754
Total												
1974.....	743,968	117,936	93,555	136,644	1,556	97,481	11,488	46,424	12,239	83,759	79,858	63,028
1975 Budget...	749,624	118,179	96,739	129,718	1,497	100,579	11,704	47,956	12,492	84,989	78,438	67,333
1975 Current..	765,175	121,612	95,896	131,316	1,673	104,833	12,100	48,335	13,173	88,104	79,921	68,212
1976.....	776,000	125,196	94,974	130,506	1,696	105,847	12,705	49,257	13,714	90,710	81,902	69,493
Transition....	213,800	34,966	29,753	34,372	423	27,740	3,543	12,749	4,907	23,387	21,936	20,024

SUM 13

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

RESEARCH AND PROGRAM MANAGEMENT

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; hire, maintenance and operation of administrative aircraft; purchase (not to exceed [sixteen] *ten* for replacement only) and hire of passenger motor vehicles; and maintenance and repair of real and personal property, and not in excess of [$10,000] *$25,000* per project for construction of new facilities and additions to existing facilities, and not in excess of [$25,000] *$50,000* per project for rehabilitation and modification of facilities; [$740,000,000] *$776,000,000*: *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 $35,000 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.

For "Research and program management," for the period July 1, 1976, through September 30, 1976, $213,800,000. (42 U.S.C. 2451, et seq.: Department of Housing and Urban Development; Space, Science, Veterans, and Certain Other Independent Agencies Appropriation Act, 1975; additional authorizing legislation to be proposed for fiscal year 1976, and for the period July 1, 1976, through September 30, 1976.)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Research and Program Management

Program and Financing (in thousands of dollars)

Identification code 27-00-0103-0-1-999		Budget plan			Costs and obligations		
		1974 actual	1975 estimate	1976 estimate	1974 actual	1975 estimate	1976 estimate
	Program by activities:						
	Direct program:						
	1. Manned space flight	320,854	318,300	319,700	321,313	318,300	319,700
	2. Scientific investigations in space	118,950	126,300	124,200	118,487	126,300	124,200
	3. Space applications	68,728	75,800	79,200	68,539	75,800	79,200
	4. Space research and technology	57,451	60,400	63,500	57,266	60,400	63,600
	5. Aeronautical research and technology	132,871	132,400	134,200	132,718	132,400	134,200
	6. Energy programs	4,380	9,175	10,900	4,394	9,175	10,900
	7. Supporting activities	40,734	42,800	44,200	40,366	42,800	44,200
	Total direct program costs, funded	743,968	765,175	776,000	743,083	765,175	776,000
	Reimbursable program:						
	1. Manned space flight	1,153	1,552	1,424	1,165	1,552	1,424
	2. Scientific investigations in space	165	200	292	170	200	292
	3. Space applications	3,429	4,948	4,772	3,495	4,948	4,772
	4. Space research and technology	856	2,019	2,232	862	2,019	2,232
	5. Aeronautical research and technology	16	81	10	17	81	10
	7. Supporting activities	112	200	170	116	200	170
	Total reimbursable program costs	5,731	9,000	8,900	5,825	9,000	8,900
	Total program costs, funded	749,699	774,175	784,900	748,908	774,175	784,900
	Change in selected resources (undelivered orders)				791		
10	Total	749,699	774,175	784,900	749,699	774,175	784,900
	Financing:						
	Receipts and reimbursements from:						
11	Federal funds				−4,226	−6,191	−6,357
14	Non-Federal sources				−1,505	−2,809	−2,543
25	Unobligated balance lapsing				632		
	Budget authority				744,600	765,175	776,000
	Budget authority:						
40	Appropriation				744,600	740,000	776,000
42	Transferred from other accounts					5,200	
43	**Appropriation (adjusted)**				744,600	745,200	776,000
44.20	**Proposed supplemental for civilian pay raises**					19,975	
	Relation of obligations to outlays:						
71	Obligations incurred, net				743,968	765,175	776,000
72	Obligated balance, start of year				62,696	52,756	53,631
74	Obligated balance, end of year				−52,756	−53,631	−53,631
77	Adjustments in expired accounts				5,629		
90	Outlays, excluding pay raise supplemental				759,537	745,000	775,325
91.20	Outlays from civilian pay raise supplemental					19,300	675

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1976 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 occupies an additional 54,080 acres at the White Sands Test Facility, Las Cruces, New Mexico. The Center's mission also requires occupancy of the Earth Resources Laboratory located at the National Space Technology Laboratories, Bay St. Louis, Mississippi. 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 June 30, 1974, was $914,010,000.

MISSION

The Lyndon B. Johnson Space Center (JSC) was established in November 1961 (initially as the Manned Spacecraft Center). Current responsibilities include manned spacecraft development, program management, flight crew selection and training, space flight operations and related medical research, life sciences, and space science and applications. The Center has major management responsibilities for the Apollo Soyuz Test Project, the Space Shuttle program, and the Earth Resources Program.

The lunar landing missions were completed in December 1972; however, JSC continued its responsibilities and functions in modifying the Apollo spacecraft to support the requirements of both the Skylab program and the Apollo Soyuz Test Project (ASTP).

The U.S.A. and the U.S.S.R. are jointly participating in the ASTP, with launch scheduled early in FY 1976. JSC has prime responsibility for the Apollo spacecraft, the docking module and docking system hardware, and development and coordination of arrangements and interfaces for this mission.

JSC, under NASA Headquarters program direction, is Lead Center for the overall planning, direction and integration of all aspects of the Space Shuttle Program. In this role, the Center manages the design, development, test, and production of the Orbiter system, as well as supporting the Space Shuttle Program Manager in the integration of all elements of the program. The Shuttle is a low cost, space transportation system that includes an Orbiter vehicle that can fly repeatedly from earth to orbit and back, thus replacing many expendable launch systems currently in use. The Shuttle program includes, in addition to Orbiters, external tanks, solid rocket

boosters, main engines, ground and flight planning and operations, and launch and landing facilities planning and implementation.

As Lead Center for the Agency's Earth Resources Program (ERP), which is a significant part of the experimental Federal Earth Resources Program, JSC coordinates the work of other NASA Centers in this enterprise. JSC also has a Project Center role in the ERP, under which it provides the focus for all Center activity related to the development and application of remote sensing devices and techniques for earth resources surveys. One of these ERP activities includes an airborne research program for development of remote sensors and data management techniques.

JSC engineering and development efforts focus on systems definition, development, evaluation and test for spacecraft development programs, as well as on applied research and technology development and advanced studies for future spacecraft systems, payloads and programs. Space science and applications efforts are devoted to the development of flight experiments, evaluation of results from scientific exploration, continuing research on return lunar materials, and space environment studies. Life Sciences capabilities include in-flight experiments, flight crew monitoring, and development of physiological requirements for manned spacecraft systems. In the area of flight operations, JSC has extensive experience and capability for mission planning, and for the overall direction of flight control activities. Flight control is executed from the Mission Control Center, utilizing the Manned Space Flight Network.

The application of NASA-developed space technology to public problems includes cooperative efforts with other Federal agencies and with several state and local governments. The Urban Systems Project Office manages, in close association with HUD, the engineering and development of an integrated utilities systems that utilizes aerospace techniques toward the achievement of more efficient public housing.

JSC's White Sands Test Facility conducts the development and testing of spacecraft engines, and performs other functions that support the overall JSC mission but are best carried out in an isolated area.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
I. Personnel and Related Costs..	$87,796	$88,992	$93,138	$94,231	$24,268
II. Travel.....	2,925	3,498	3,232	3,666	1,015
III. Facilities Services.....	11,192	11,423	12,290	13,110	4,964
IV. Technical Services.....	7,199	6,048	5,986	6,707	2,156
V. Administrative Support.....	8,824	8,218	6,966	7,482	2,563
VI. Total, fund requirements....	$117,936	$118,179	$121,612	$125,196	$34,966

Over two-thirds of Johnson's permanent positions are used in direct support of the various R&D programs. The following table summarizes the actual and planned utilization of positions for direct program activity and for indirect support.

Distribution of Permanent Positions by Program

Direct Positions

Manned Space Flight

Space shuttle....	1,644	1,693	1,870	2,248	2,248
Space flight operations.....	974	909	745	358	358
Advanced missions.....	17	17	20	31	31
Apollo.....	3	6	2	---	---

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
Space Science					
Physics and astronomy.....	28	14	29	34	34
Lunar and planetary exploration...	50	70	56	54	54
Applications					
Space applications..	319	365	297	297	297
Aeronautics and Space Technology					
Aeronautical research and technology....	7	4	7	5	5
Space and nuclear research and technology....	4	4	3	3	3
Energy					
Energy technology applications..	32	--	33	33	33
Technology Utilization.....	14	8	6	5	5
Subtotal, direct positions...	3,092	3,090	3,068	3,068	3,068
Indirect Positions					
Director and staff.....	111	114	115	115	115
Administrative support.....	166	396	164	164	164
Research and technology support.....	283	52	266	266	266

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Dollars in Thousands)			
Subtotal, indirect positions.....	560	562	545	545	545
Total, permanent positions.	3,652	3,652	3,613	3,613	3,613
PERSONNEL AND RELATED COSTS					
I. PERSONNEL AND RELATED COSTS.....	$87,796	$88,992	$93,138	$94,231	$24,268
Basis of Fund Requirements					
A. Compensation and Benefits:					
1. Compensation					
a. Permanent positions.....	$77,130	$78,229	$81,952	$83,032	$21,180
b. Nonpermanent positions.....	1,106	1,259	1,318	1,194	365
c. Reimbursable...	1,043	1,173	1,000	922	232
d. Overtime and other compensation.....	1,157	1,078	1,069	1,081	270
Subtotal, Compensation...	$80,436	$81,739	$85,339	$86,229	$22,047
2. Benefits.....	$6,814	$6,823	$7,336	$7,542	$2,051
Subtotal, Compensation and Benefits.....	$87,250	$88,562	$92,675	$93,771	$24,098
B. Supporting Costs:					
1. Transfer of personnel.....	$128	$100	$133	$110	$20
2. Personnel training.....	388	330	330	350	150

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
3. Civil Service Commission services.....	$30	---	---	---	---
Subtotal, Supporting Costs.....	$546	$430	$463	$460	$170
Total, Personnel and Related Costs.....	$87,796	$88,992	$93,138	$94,231	$24,268
1. Compensation.....	$80,436	$81,739	$85,339	$86,229	$22,047
a. Permanent positions.....	$77,130	$78,229	$81,952	$83,032	$21,180

The current estimate for 1975 is increased from the 1975 budget estimate to reflect the October 1974 pay raise. This is partially offset by the savings resulting from the reduction in manpower from 3,652 to 3,613.

The increase in 1976 is primarily the full year net cost of these actions.

Basis of Cost for Permanent Positions

In 1976, the cost of permanent positions will be $83,032. This is an increase of $1,080 from 1975. This increase results from the following:

Cost of permanent positions in 1975.....		$81,952
Cost increases:		+3,021
Within grade advances and career development		
Full year effect of 1975 actions.....	+$693	
Partial year effect of 1976 actions.....	+746	
Full year effect of October 1974 pay raise...	+1,263	
Additional extra day.....	+319	
Cost decreases:		-1,941
Full year effect of 1975 manpower reductions	-$836	
Turnover savings		
Full year effect of 1975 actions.....	-427	
Partial year effect of 1976 actions.....	-678	
Cost of permanent positions in 1976.....		$83,032

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Dollars in Thousands)			
b. Nonpermanent positions:					
1. Cost	$1,106	$1,259	$1,318	$1,194	$365
2. Number of manyears	168	201	198	175	54

The 1976 program includes 175 manyears to support the following programs::

Distribution of Nonpermanent Manyears by Program

	Positions
College cooperative training	65
Summer employment	11
Opportunity programs	77
Other temporary employment	19
Other	3
Total	175

The current estimate for 1975 is increased from the 1975 budget estimate due to the October 1974 pay raise. The decrease in the 1976 estimate is due to a sizeable reduction in the temporary clerical employment consistent with the completion of the Skylab Program. This reduction is partially offset to provide more emphasis on the minority and female opportunity program.

c. Reimbursable details	$1,043	$1,173	$1,000	$922	$232

The military personnel detailed to the Johnson Space Center on a reimbursable basis are personnel experienced in manned flight or related fields. Each individual performs an essential function in carrying out agency programs.

From the inception of the Johnson Space Center, it was recognized that the experience and knowledge of individuals with a "flight" background would be essential to the manned space flight programs. One civilian employee is also detailed, on a reimbursable basis, to the Johnson Space Center. This is an individual whose experience in the field of medicine is essential. The lower current estimate for 1975 reflects a reduction of 14 manyears as detailees in completed work are not replaced as originally planned. The 1976 decrease is related to a further reduction of six military detailees.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
d. Overtime and other compensation.....	$1,157	$1,078	$1,069	$1,081	$270

The major portion (approximately 83%) of overtime and holiday pay is used for long duration chamber tests, preparation and operation of astronauts for training simulators and those maintenance and repair operations that must be accomplished on non-scheduled work days. The remaining portion (approximately 17%) of overtime and holiday pay is used for peak work load periods, i.e., Source Evaluation Boards, fiscal year-end closing, etc. The decrease from the 1975 budget estimate is the net result of efforts to curtail overtime and additional costs of the October 1974 pay raise. The 1976 estimate reflects the full year cost of the pay raise.

2. Benefits:	$6,814	$6,823	$7,336	$7,542	$2,051

The current estimate for 1975 is increased from the 1975 budget estimate to account for a higher base for retirement; an increase of 20% in the Government's share of the contribution for health insurance. The increases were partially offset by a reduction in the number of awards and elimination of the previously planned RIF. The increase in 1976 is attributable to the full year costs of these actions.

The distribution of these costs by major categories is as follows:

Category of Costs					
Contribution to the Civil Service Retirement Fund.....	$5,418	$5,485	$5,792	$5,877	$1,666
Contribution for employees life insurance.....	266	290	257	260	66
Contribution for employees health insurance.....	914	780	1,183	1,300	304

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Cateogry of Cost (Cont'd)					
Contribution to FICA	44	46	49	50	10
Incentive awards	54	90	55	55	5
Other personnel benefits	1	1	---	---	---
Severence pay	117	131			
Total	$6,814	$6,823	$7,336	$7,542	$2,051
B. Supporting Costs	$546	$430	$463	$460	$170
1. Transfer of personnel	$128	$100	$133	$110	$20
2. Personnel training	388	330	330	350	150
3. Civil Service Commission	30	---	---	---	---
1. Transfer of personnel	$128	$100	$133	$110	$20

The current estimate for 1975 is increased over the budget estimate to pay for additional moves. This was necessitated by the movement of Reliability and Quality Assurance personnel to the contractor plant at Downey, California. The decrease in 1976 is based on fewer anticipated moves.

2. Personnel training	$388	$330	$330	$350	$150

The personnel training costs for 1976 are based on continuation of current training programs and the need to reorient skills of employees into areas compatible with the direction of the space program in the 1970's and JSC's role in the program. A prime objective is career development to permit employees to advance to more responsible positions and to provide the center with highly motivated and experienced personnel not readily available in the labor market. The increase (6%) is attributable to an increase in tuition fees, text books, and training courses costs.

TRAVEL

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
II. TRAVEL.....	$2,925	$3,498	$3,232	$3,666	$1,015

Over 82% of the total JSC travel estimate is Program Related travel. Because of the complexity of the Research and Development programs and the distribution of contractor effort throughout the entire United States, coordination and management of activities and contract monitoring require frequent examination by personnel responsible for the program. The Apollo Soyuz Test Project will peak during 1975. In 1976, the Shuttle Program will be nearing a maximum level of activity.

Basis of Fund Requirements

Summary of Travel by Major Category

A. Program related travel.....	$2,231	$2,426	$2,653	$3,057	$837
B. Meetings and technical seminars.....	287	337	165	179	49
C. Administrative travel.....	407	735	414	430	129
Total, Travel.....	$2,925	$3,498	$3,232	$3,666	$1,015
A. Program related travel.....	$2,231	$2,426	$2,653	$3,057	$837

The current estimate for 1975 is increased over the 1975 budget estimate to reflect essential program travel predominantly associated with the Shuttle and ASTP programs. Offsetting adjustments have been made in the Meeting and Administrative travel categories. The higher 1976 requirement increases because the Space Shuttle program will have reached the critical Design and Development Phase, necessitating hardware reviews and close configuration and contract monitoring. Higher air tariffs are also reflected here.

B. Meetings and technical seminars.....	$287	$337	$165	$179	$49
C. Administrative travel.....	$407	$735	$414	$430	$129

The current estimate for 1975 is reduced from the 1975 budget estimate to reflect the recent legislation limiting Federal travel expenses and the curtailment of Meeting and Administrative travel to insure that essential Program Related travel requirements are met. Travel requirements for 1976 are estimated at the 1975 level and adjusted to take into account increased air tariffs.

FACILITIES SERVICES

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
III. FACILITIES SERVICES....	$11,192	$11,423	$12,290	$13,110	$4,964

Basis of Fund Requirements

Summary of Facilities Services

A. Maintenance and Related Services					
1. Maintenance, repair and alteration of buildings and grounds.....	$5,390	$3,648	$5,199	$5,340	$1,675
2. Custodial services.....	2,500	2,983	2,965	3,216	1,789
3. Maintenance of equipment.....	204	282	347	403	150
Subtotal.....	$8,094	$6,913	$8,511	$8,959	$3,614
B. Operation of Facilities					
1. Utilities.....	$2,048	$2,771	$2,757	$3,151	$1,070
2. Supplies and equipment.....	1,050	1,739	1,022	1,000	280
Subtotal.....	$3,098	$4,510	$3,779	$4,151	$1,350
Total, Facilities Services..	$11,192	$11,423	$12,290	$13,110	$4,964
A. Maintenance and Related Services.....	$8,094	$6,913	$8,511	$8,959	$3,614
1. Maintenance, repair and alteration of buildings and grounds.....	$5,390	$3,648	$5,199	$5,340	$1,675

The current estimate for 1975 is increased over the 1975 budget estimate due to increased support contractor wage rates, and a recategorization of supplies and equipment costs to this subfunction. The 1975 budget estimate was based on a plan to issue Government supplies and equipment to the maintenance contractor. However, this was not feasible because the contract was subsequently divided among four companies. Procurement cycle demands and requirements for many nonstandardized items made the plan impractical, with the result that supplies and equipment are now purchased by the individual contractors. An offsetting reduction has been made in the supplies and equipment category below. The increase for 1976 is based on the full year effect of increased support contract wage rates and Shuttle Program buildup at the White Sands Test Facility. The significantly heavier use of WSTF facilities as the Shuttle buildup proceeds will produce higher maintenance and operating costs.

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
2. Custodial services	$2,500	$2,983	$2,965	$3,216	$1,789

This category includes security, fire protection, ambulance, and janitorial services. The current estimate for 1975 remains essentially the same as the 1975 budget estimate. The increase in 1976 provides for the full year effect of increased support contractor wage rates.

3. Maintenance of equipment	$204	$282	$347	$403	$150

The current estimate for 1975 is increased over the 1975 budget estimate due to purchase of leased office equipment late in 1974. Previous lease arrangements included maintenance and repair which are now purchased. The increase in 1976 is also attributable to the purchase of leased equipment with delivery in 1975 and the need to provide maintenance and repair.

B. Operation of Facilities	$3,098	$4,510	$3,779	$4,151	$1,350
1. Utilities	$2,048	$2,771	$2,757	$3,151	$1,070

The current estimate for 1975 is decreased from the budget estimate as a result of implementation of energy conservation measures at JSC that have reduced costs. In 1976 these energy conservation measures will be continued but will be offset by higher rate charges taking place in 1975.

2. Supplies and equipment	$1,050	$1,739	$1,022	$1,000	$280

51-423 O - 75 - 44

The current estimate for 1975 was decreased from the 1975 budget estimate to reflect the recategorization of costs for supplies and materials to the maintenance, repair and alteration of buildings and grounds category above. The slight decrease in 1976 is attributable to the Center's policy to reduce supply expenditures.

TECHNICAL SERVICES

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
IV. TECHNICAL SERVICES.....	$7,199	$6,048	$5,986	$6,707	$2,156

Basis of Fund Requirements

Summary of Technical Services

A. Automatic Data Processing					
1. Equipment.....	$3,109	$2,613	$1,975	$2,026	$550
2. Programming and operation services.....	1,994	1,756	1,956	2,239	605
Subtotal.....	$5,103	$4,369	$3,931	$4,265	$1,155
B. Engineering Services....	$325	$189	$407	$447	$120
C. Scientific and Technical Information and Educational Programs					
1. Technical library...	$80	$80	$80	$82	$25
2. Educational/informational programs.	446	399	427	499	140
3. Scientific and technical information.....	1,245	1,011	1,141	1,414	716
Subtotal.....	$1,771	$1,490	$1,648	$1,995	$881
Total, Technical Services...	$7,199	$6,048	$5,986	$6,707	$2,156

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Automatic Data Processing.....	$5,103	$4,369	$3,931	$4,265	$1,155

The current estimate for 1975 was decreased from the 1975 budget estimate to reflect the purchase of leased equipment late in 1974 which reduced equipment costs. The decrease was partially offset by an increase in programming and operations effort required to update financial and management accounting systems and higher support contractor rates. The increase in the 1976 estimate is the full year effect of higher wage rates.

B. Engineering Services....	$325	$189	$407	$447	$120

The current estimate for 1975 is increased over the 1975 budget estimate due to the addition of costs in this category that were previously reported in the Administrative Support function as well as for wage increases. A corresponding reduction is reflected in the Administrative Support function. The increase in the 1976 estimate is the full year effect of higher contractor wage rates.

C. Scientific and Technical Information and Educational Programs.....	$1,771	$1,490	$1,648	$1,995	$881
1. Technical library...	$80	$80	$80	$82	$25

The technical library acquires approximately 14,000 units a year. The 1976 estimate reflects wage escalation.

2. Educational/informational programs.	$446	$399	$427	$499	$140

The current estimate for 1975 is increased over the 1975 budget estimate for support contract wage increases. The increase in the 1976 estimate is the full year effect of higher wage rates for existing contracts.

3. Scientific and technical information.....	$1,245	$1,011	$1,141	$1,414	$716

The current estimate for 1975 is increased over the 1975 budget estimate for support contractor wage increases. The increase in the 1976 estimate is the full year effect of higher wage rates on existing contracts.

ADMINISTRATIVE SUPPORT

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
V. ADMINISTRATIVE SUPPORT	$8,824	$8,218	$6,966	$7,482	$2,563

Basis of Fund Requirements

Summary of Administrative Support

A. Communications					
1. Leased lines and long distance tolls	$894	$896	$914	$865	$234
2. Local telephone services	995	1,008	1,069	1,075	290
3. Other communications	105	129	128	117	32
Subtotal	$1,994	$2,033	$2,111	$2,057	$556
B. Administrative Printing	$625	$820	$591	$525	$142
C. Supplies, Materials and Equipment	$2,788	$1,654	$1,237	$1,134	$306
D. Transportation					
1. Center operations	$473	$530	$475	$543	$150
E. Administrative Support Services					
1. Installation support	$1,888	$2,213	$1,725	$2,108	$1,104
2. Occupational medicine and environmental health	1,056	968	827	1,115	305
Subtotal	$2,944	$3,181	$2,552	$3,223	$1,409
Total, Administrative Support	$8,824	$8,218	$6,966	$7,482	$2,563

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Communications.....	$1,944	$2,033	$2,111	$2,057	$556

The current estimate for 1975 is increased over the 1975 budget estimate to account for rate increases in maintenance, repair, installation, and relocation of telephone instruements. The decrease in 1976 reflects the planned reduction of FTS costs.

B. Administrative Printing.....	$625	$820	$591	$525	$142

The current estimate is reduced from the 1975 budget estimate as a result of Post-Skylab and ASTP printing requirements being substantially lower than planned. The previous estimate was based on Post-Apollo printing experience. The decrease in 1976 is related to reduction in ASTP requirements.

C. Supplies, Materials and Equipment.....	$2,788	$1,654	$1,237	$1,134	$306

The current estimate for 1975 is reduced from the 1975 budget estimate due to lower lease costs resulting from the purchase of leased equipment late in 1974, as well as JSC's policy to reduce supply expenditures. The decrease in 1976 reflects the full year savings of these actions.

D. Transportation.....	$473	$530	$475	$543	$150

The current estimate for 1975 is reduced from the 1975 budget estimate as a result of an energy conservation program at JSC. The 1976 increase reflects requirements for scheduled overhaul of engines on the administrative aircraft and escalation of GSA rental rates.

E. Administrative Support Services.....	$2,944	$3,181	$2,552	$3,223	$1,409

The current estimate for 1975 is reduced from the 1975 budget estimate as a result of a reclassification of costs to the technical service function, as well as the consolidation of two medical support service contracts which further reduced costs. The 1976 increase reflects the full year effect of higher wage rates for existing contracts.

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1976 ESTIMATES

JOHN F. KENNEDY SPACE CENTER

DESCRIPTION

Operations at the John F. Kennedy Space Center are conducted at two primary locations:

1. At the Kennedy Space Center, which is situated approximately 50 miles east of Orlando, Florida, in northeast Brevard County. The total land and water area occupied by the installation is 140,393 acres. Breakdown of this acreage is as follows:

NASA-Owned	84,031
Easement, Banana River Causeway	271
Easement, Indian River Causeway	296
Deed of Dedication, Florida-Owned, Submerged Lands	55,795
Total	140,393

In addition, the Kennedy Space Center is responsible for the operation and maintenance of certain facilities within the Eastern Test Range launch area.

2. At the Western Test Range, which is located at Vandenberg Air Force Base, in Santa Barbara County, 6 miles west of Lompoc, California, and 160 miles north of Los Angeles, California. Unmanned launch operations are accomplished through a host-tenant agreement with the Air Force.

The total capital investment at the Kennedy Space Center and the Western Test Range, including fixed assets in progress and contractor-held facilities at various locations as of June 30, 1974, was $1,307,186,000.

MISSION

The Kennedy Space Center was established at Cape Canaveral, Florida, as a separate Center within NASA in July 1962. It serves as the primary Center for the test, checkout, and launch of space vehicles. This presently includes launch of manned and unmanned vehicles at the Kennedy Space Center, the Air Force Eastern Test Range, and the Air Force Western Test Range. The Apollo Soyuz Test Project is scheduled to be launched at KSC early in FY 1976. Concurrently, KSC is carrying forward the design and development of launch and landing facilities and ground support equipment for the Shuttle program.

The Kennedy Space Center is specifically responsible for:

1. Launch vehicle preparation and checkout.

2. Spacecraft and payload preparation and checkout.

3. Launch facility design, construction, maintenance, and operations, including advanced planning and studies leading to development of new launch operation concepts and techniques.

4. Final integration and integrated checkout of vehicle, spacecraft and launch facilities, and the conduct of actual launch operations.

5. Operation and coordination of supporting facilities, ground support equipment, and tracking and data acquisition and logistics support required for operation of all NASA activities at the Eastern and Western Test Ranges.

6. Technical and administrative support services for all NASA elements located in the area.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

Functions	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
I. Personnel and Related Costs...	$51,749	54,291	$53,717	$54,242	$14,587
II. Travel.....	1,625	1,456	1,582	1,764	664
III. Facilities Services.....	25,179	25,972	25,452	24,488	8,961
IV. Technical Services	6,462	6,167	5,487	5,180	2,190
V. Administrative Support.....	8,540	8,853	9,658	9,300	3,351
Total, fund requirements....	$93,555	$96,739	$95,896	$94,974	$29,753

Distribution of Permanent Positions by Program

Over two-thirds of Kennedy's permanent positions are used in direct support of the various R&D programs. The following table summarizes the actual and planned utilization of positions for direct program activity and for indirect support.

Direct Positions	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
Manned Space Flight					
Space shuttle	727	423	653	1,223	1,223
Space flight operations	744	1,025	755	161	161
Advanced missions	5	2	5	5	5
Space Science					
Launch vehicle operations	259	257	274	292	292
Applications					
Space applications	23	27	34	40	40
Aeronautics and Space Technology					
Space and nuclear research and technology	2	---	3	3	3
Subtotal, positions by program	1,760	1,734	1,724	1,724	1,724
Indirect Positions					
Director and staff	93	92	93	93	93
Administrative support	401	428	387	387	387
Research and development support	55	55	55	55	55
Subtotal, indirect positions	549	575	535	535	535
Total, permanent positions	2,309	2,309	2,259	2,259	2,259

PERSONNEL AND RELATED COSTS

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
I. PERSONNEL AND RELATED COSTS.....	$51,749	$54,291	$53,717	$54,242	$14,587
Basis of Fund Requirements					
A. Compensation and Benefits:					
1. Compensation:					
a. Permanent positions.....	$46,541	$48,692	$47,956	$48,226	$12,945
b. Nonpermanent positions.....	629	670	679	676	250
c. Reimbursable details.....	19	---	28	103	26
d. Overtime and other compensation..	296	426	460	389	111
Subtotal, Compensation..	$47,485	$49,788	$49,123	$49,394	$13,332
2. Benefits:	$4,020	$4,118	$4,174	$4,428	$1,149
Subtotal, Compensation and Benefits.....	$51,505	$53,906	$53,297	$53,822	$14,481
B. Supporting Costs:					
1. Transfer of personnel.....	$43	$60	$70	$70	$18
2. Personnel training..	201	325	350	350	88
Subtotal, Supporting Costs.....	$244	$385	$420	$420	$106
Total, Personnel and Related Costs.....	$51,749	$54,291	$53,717	$54,242	$14,587
1. Compensation.....	$47,485	$49,788	$49,123	$49,394	$13,332
a. Permanent positions.	$46,541	$48,692	$47,956	$48,226	$12,945

The current estimate for 1975 is decreased $736 from the 1975 budget estimate due to a reduction in the personnel ceiling of 50 positions and a reduction to NASA costs to reflect reimbursements for launch services received from other users. These reductions are partially offset by the cost of the October 1974 civil service pay raise. The increase of $270 in 1976 reflects the full year cost of the 1974 pay raise, plus the cost of promotions and within-grade advances, and the extra day in 1976 partially offset by the full year's savings of the 1975 employment reduction.

Basis of Cost for Permanent Positions
(Thousands of Dollars)

In 1976 the cost of permanent positions will be $48,226 an increase of $270 from 1975. This increase results as follows:

Cost of permanent positions in 1975		$47,956
Cost increases:		+1,773
Within grade advances and career development		
Full year effect of 1975 actions	+$490	
Partial year effect of 1976 actions	+492	
Full year effect of October 1974 pay raise	+605	
Additional extra day	+186	
Cost decreases:		-1,503
Full year effect of 1975 manpower reductions	-$720	
Turnover savings		
Full year effect of 1975 actions	-394	
Partial year effect of 1976 actions	-389	
Cost of permanent positions in 1976		$48,226

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Dollars in Thousands)			
b. Nonpermanent positions					
1. Cost	$629	$670	$679	$676	$250
2. Number of manyears	97	96	100	100	37

The FY 1976 plan includes 100 manyears to support the following programs:

Distribution of Nonpermanent Manyears by Program

	Manyears
College Cooperative Training	47
Summer Employment	10
Opportunity Programs	31
Other Temporary Employment	12
Total	100

The current estimate for 1975 is increased from the 1975 budget estimate primarily as a result of the October 1974 pay increase. The program for 1976 is planned at the 1975 level.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
			(Thousands of Dollars)		
c. Reimbursable details	$19	---	$28	$103	$26

The current estimate for 1975 includes funding for the services of two Air Force senior engineers who are participating in the Shuttle program development (i.e., software applications and GSE requirements). Three additional Air Force engineers and a logistician will come on board in 1976 and will also participate in Shuttle development (i.e., maintainability and flight test support). 1976 reflects the full year cost of these six Air Force personnel.

d. Overtime and other compensation	$296	$426	$460	$389	$111

The major requirement for overtime is in direct support of test, integration and checkout of vehicle subsystems and systems, and in preparation of the total vehicle (including spacecraft) for launch. The current estimate for 1975 allows for a general schedule salary increase not included in the 1975 budget estimate. The decrease in 1976 is a result of continuing efforts to reduce overtime costs to the lowest level consistent with mission requirements. The amount of overtime required in each fiscal year is substantially a function of launch rate activity.

2. Benefits	$4,020	$4,118	$4,174	$4,428	$1,149

The following table distributes these costs by major categories:

Category of Cost	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Contribution to the Civil Service Retirement Fund..	$3,274	$3,450	$3,401	$3,497	$940
Contribution for employee life insurance.....	171	155	182	192	49
Contribution to employee health insurance.....	546	430	566	714	154
FICA.....	16	16	17	17	5
Incentive awards....	7	15	8	8	1
Severance pay.....	6	52	---	---	---
Total.....	$4,020	$4,118	$4,174	$4,428	$1,149

The current estimate for 1975 has increased over the 1975 budget estimate due to the large increase in the cost of health insurance rates. In addition, the Government's contribution to Federal Health Insurance was increased effective January 1975. The overall increase of $254 in 1976 is primarily for the full year's cost of the health insurance rate increase and the increased Government contribution.

B. Supporting Costs.....	$244	$385	$420	$420	$106
1. Transfer of personnel	$43	$60	$70	$70	$18

The estimated cost in 1975 and 1976 is based on anticipated additional cost per hire as recruitment efforts extend beyond the Southeastern Region.

2. Personnel training...	$201	$325	$350	$350	$88

The current estimate for 1975 is increased by $25 from the 1975 budget estimate reflecting the need for preparing the work force for Shuttle flight operations and reflecting increased activity in the Upward Mobility Program The 1976 estimate reflects a continuation of the 1975 level.

TRAVEL

II. TRAVEL.....	$1,625	$1,456	$1,582	$1,764	$664

Basis of Fund Requirements

Summary of Travel by Major Category

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Program Travel.....	$535	$609	$609	$778	$414
B. Meetings and Technical Seminars.....	97	43	43	46	19
C. Administrative Travel...	993	804	930	940	231
Total, Travel.....	$1,625	$1,456	$1,582	$1,764	$664
A. Program Travel.....	$535	$609	$609	$778	$414

The current estimate for 1975 reflects the effect of the recent legislation reducing Federal travel expenses, but is offset by an increase attributable to the KSC role in development of the Shuttle program, particularly in the area of launch and landing systems and facilities.

The 1976 program travel is further increased to support the accelerating pace of KSC's Shuttle ground systems development activities and includes costs for increased air fares.

B. Meetings and Technical Seminars.....	$97	$43	$43	$46	$19

The 1976 travel is continued at the 1975 level, adjusted to take into account increased air fares.

C. Administrative Travel...	$993	$804	$930	$940	$231

Administrative travel includes the services provided by the GSA motor pool operation, which constitutes over 80% of Administrative travel. The current estimate for 1975 is increased from the 1975 budget estimate due to increased GSA rate schedules for the motor pool. The 1976 travel is continued at the 1975 level, adjusted to take into account increased air fares.

FACILITIES SERVICES

III. FACILITIES SERVICES...	$25,179	$25,972	$25,452	$24,488	$8,961

Basis of Fund Requirements

Summary of Facilities Services

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Rental of Real Property	$29	$10	$35	$5	$5
B. Maintenance and Related Services					
1. Maintenance, repair and alterations of buildings and grounds	$10,060	$10,810	$10,285	$8,970	$3,518
2. Custodial services	7,875	8,332	6,866	7,047	3,202
3. Maintenance of equipment	348	376	377	404	136
Subtotal	$18,283	$19,518	$17,528	$16,421	$6,856
C. Operation of Facilities					
1. Utilities	$4,064	$4,247	$5,165	$5,365	$1,379
2. Supplies and equipment	2,803	2,197	2,724	2,697	721
Subtotal	$6,867	$6,444	$7,889	$8,062	$2,100
Total, Facilities Services	$25,179	$25,972	25,452	$24,488	$8,961

This category covers the cost of operating and maintaining the institutional facilities at Kennedy Space Center and NASA facilities at the Air Force Eastern Test Range, Cape Canaveral Air Force Station, Florida, and the Air Force Western Test Range, Vandenberg AFB, California. The dry land area exceeds 130 square miles. The size and the wide geographical distribution of facilities within KSC generate extremely heavy demand for facility services. Two hundred seventy five structural facilities contain 4.7 million square feet and require 25,000 tons of air conditioning; 12 heating plants; 212 linear miles of electrical lines and 150 unit substations; 23,000 linear feet of sewer lines, 15 sewage treatment plants, and 24 sewage lift stations; 18 elevators; 4 water storage tanks with a total capacity of 2.5 million gallons; and 231,000 linear feet of water lines. The roadway system includes 225 miles of highways and roads, and

3 bridges (2 over the Intracoastal Waterway). The Center is also responsible for 18 miles of navigable canals and channels and 87 square miles of submerged lands.

For economy reasons, KSC provides common base support to contractor employees as well as civil service employees. Costs are significantly affected by the on-site contractor population which is larger than the civil service population.

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Rental of Real Property	$29	$10	$35	$5	$5

The current estimate for 1975 is increased from the 1975 budget estimate due to an earlier requirement for rented space for the news media activity related to the ASTP launch. The reduction in the 1976 estimate reflects completion of ASTP. The Transition Period reflects the Center's normal obligation practice.

B. Maintenance and Related Services	$18,283	$19,518	$17,528	$16,421	$6,856
1. Maintenance, repair and alterations of buildings and grounds	$10,060	$10,810	$10,285	$8,970	$3,518

The current estimate for 1975 has been decreased from the 1975 budget estimate as a result of the Center's concentrated efforts to downmode facilities and excess equipment consistent with launch schedules. These efforts have also resulted in reduced maintenance requirements which will continue into 1976.

2. Custodial services.	$7,875	$8,332	$6,866	$7,047	$3,202

Services included in this category are security at KSC and Cape Canaveral Air Force Station (CCAFS), fire protection at KSC, janitorial services for KSC and NASA facilities at CCAFS and WTR, and minor contracts for refuse handling and laundry services. Security, fire protection, and janitorial services are provided by support contractors. The decrease in the current estimate for 1975 from the 1975 budget estimate reflects a change in the contract funding plan for janitorial services and a reduction in contractor manpower for security services. In 1976, janitorial services will be reduced further, but will be offset by the full year effect of contractor wage rate increases and an increased requirement for security services at ETR due to the Viking launch complex reaching full activation.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
3. Maintenance of equipment.....	$348	$376	$377	$404	$136

The level of service in 1976 will continue at the same rate as in 1975; however, the 1976 estimate reflects the full year cost of price escalation for materials and labor.

C. Operation of Facilities.....	$6,867	$6,444	$7,889	$8,062	$2,100
1. Utilities.....	$4,064	$4,247	$5,165	$5,365	$1,379

The current estimate for 1975 is increased over the 1975 budget estimate by 22% to reflect higher utility rates which are primarily a result of higher fuel costs. The increase in 1976 reflects the full year cost of utility rate increases, offset partially by a decrease in consumption.

2. Supplies and equipment.....	$2,803	$2,197	$2,724	$2,697	$721

The current estimate for 1975 is increased over the 1975 budget estimate because of higher unit prices of petroleum and other petroleum base products. The decrease in 1976 represents a general reduction in the level of inventory consistent with the completion of ASTP. The decrease is partially offset, however, by price escalation.

TECHNICAL SERVICES

IV. TECHNICAL SERVICES.....	$6,462	$6,167	$5,487	$5,180	$2,190

Basis of Fund Requirements

Summary of Technical Services

A. Automatic Data Processing					
1. Equipment.....	$119	$133	$133	$133	$47
2. Programming and operation services.	2,274	2,267	2,251	2,282	1,045
Subtotal.....	$2,393	$2,400	$2,384	$2,415	$1,092

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
B. Scientific and Technical Information and Educational Programs.....					
1. Operation of NASA technical libraries.....	$226	$161	$211	$201	$190
2. Educational/informational programs..	201	571	145	94	30
3. Scientific and technical information.....	3,642	3,035	2,747	2,470	878
Subtotal.....	$4,069	$3,767	$3,103	$2,765	$1,098
Total, Technical Services.....	$6,462	$6,167	$5,487	$5,180	$2,190
A. Automatic Data Processing.....	$2,393	$2,400	$2,384	$2,415	$1,092
1. Equipment.....	$119	$133	$133	$133	$47
The 1976 estimate reflects operations at the 1975 level.					
2. Programming and operating services.	$2,274	$2,267	$2,251	$2,282	$1,045

The current estimate for 1975 is decreased from the 1975 budget estimate as a result of contract savings in planned overtime requirements. This decrease is partially offset by an increase due to the recategorization of supplies and materials in the amount of $130 from Scientific and Technical Information to this function. The 1976 estimate reflects essentially the same level of activity for these services as in 1975, with some price escalation in the key punch services contract.

B. Scientific and Technical Information and Educational Programs.....	$4,069	$3,767	$3,103	$2,765	$1,098
1. Operation of technical libraries....	$226	$161	$211	$201	$190

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The KSC library is operated by a support contractor and currently contains over 31,000 books and bound journals; 168,000 technical documents; 650,000 microfilm documents; and 185,000 specifications and standards.

The current estimate for 1975 has increased from the 1975 budget estimate due to a recategorization of supplies and materials in the amount of $50 from Scientific and Technical Information to this function.

1976 reflects essentially the same level of activity as 1975. The transition period reflects the Center's normal practice of funding the contract for a full contract year on the renewal data.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
2. Educational/information programs...	$201	$571	$145	$94	$30

Funding 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.

The current estimate for 1975 was decreased from the budget estimate to reflect the cancellation of exhibits for the proposed Visitor Information Center expansion.

The decrease in the 1976 estimate reflects a reduction in support contractor manpower as a further economy measure.

3. Scientific and technical information.....	$3,642	$3,035	$2,747	$2,470	$878

Scientific and technical information services are provided to the total KSC work force and include documentation, printing and reproduction, publication, photographic and translation services.

The current estimate for 1975 was decreased from the 1975 budget estimate due in part to a redistribution of supplies and materials in the amount of $180 to the automatic data processing function and technical libraries function.

The decrease in 1976 reflects a reduction of 19 support contractor man-years as a result of anticipated greater economies in this area.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
V. ADMINISTRATIVE SUPPORT.....	$8,540	$8,853	$9,658	$9,300	$3,351

Basis of Fund Requirements

Summary of Administrative Support

A. Communications					
1. Leased lines and long distance tolls.....	$553	$713	$757	$757	$165
2. Local telephone service.....	1,193	880	1,143	1,116	281
3. Other communications	104	112	96	94	30
Subtotal.....	$1,850	$1,705	$1,996	$1,967	$476
B. Administrative Printing.	$128	$143	$284	$292	$116
C. Supplies, Materials, and Equipment.....	$839	$911	$752	$823	$238
D. Transportation					
1. Center operations...	$952	$720	$1,165	$1,053	$356
2. Common carrier.....	121	106	126	127	37
Subtotal.....	$1,073	$826	$1,291	$1,180	$393
E. Administrative Support Services					
1. Installation support services.....	$3,764	$4,730	$4,499	$4,285	$1,504
2. Occupational medicine and environmental health.....	886	538	836	753	624
Subtotal.....	$4,650	$5,268	$5,335	$5,038	$2,128
Total, Administrative Support.....	$8,540	$8,853	$9,658	$9,300	$3,351

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Communications.....	$1,850	$1,705	$1,996	$1,967	$476

The current estimate for 1975 is increased over the 1975 budget estimate to reflect current FTS rates. The decrease in 1976 represents a reduction in telephone instruments due to completion of ASTP, partially offset by rate increases.

B. Administrative Printing.	$128	$143	$284	$292	$116

The current estimate for 1975 is increased over the 1975 budget estimate in order to support increased Shuttle requirements. The increase in 1976 reflects the full year cost of wage and price adjustments.

C. Supplies, Materials, and Equipment.....	$839	$911	$752	$823	$238

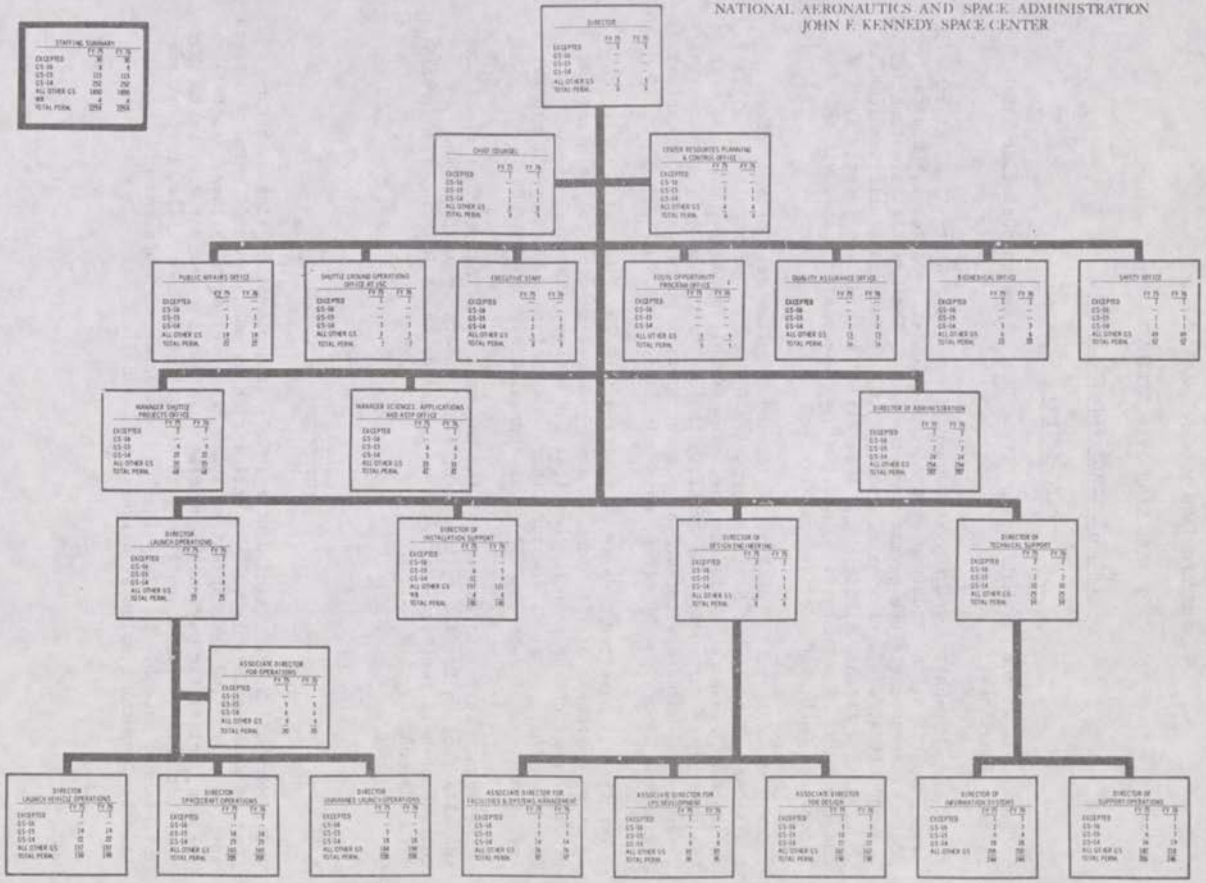
The current estimate for 1975 is reduced from the 1975 budget estimate as a result of a Center-wide economy drive to reduce costs. The increase in 1976 results primarily from price escalation for supplies and equipment.

D. Transportation.....	$1,073	$826	$1,291	$1,180	$393

The increased estimate for 1975 over the budget estimate reflects the cost of engine replacement and instrumentation overhaul on the Gulfstream aircraft. Additionally, the 1975 estimate includes a greater than originally anticipated number of trucks to support the unmanned launch activity and increased requirements for facility modifications and minor construction in support of the Shuttle program. The decrease in 1976 is a return to a normal aircraft maintenance level partially offset by cost escalation.

E. Administrative Support Services.....	$4,650	$5,268	$5,335	$5,038	$2,128

The current estimate for 1975 is increased from the 1975 budget estimate as a result of an increase in support contractor manpower performing environmental health functions based on required conformance to the Occupational Safety and Health Act standards. The decrease in 1976 reflects a support contractor manpower reduction of 28 manyears in the logistics functional area due to completion of ASTP.



RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1976 ESTIMATES

MARSHALL SPACE FLIGHT CENTER

DESCRIPTION

Operations at the Marshall Space Flight Center are conducted at three primary locations:

The main Marshall Space Flight Center site is near Huntsville, Alabama on Army property at the Redstone Arsenal. The Center occupies 1,840 acres under a nonrevocable use permit from the Army. The capital investment as of June 30, 1974, was approximately $420,285,000. Certain facilities such as the Redstone Arsenal Airfield and some utilities are used jointly by NASA and the Army. The Huntsville location has a deepwater access via the Tennessee, Ohio, and Mississippi Rivers.

The Michoud Assembly Facility is located 15 miles east of New Orleans, Louisiana. The Michoud Facility occupies 891 acres and provides 3,557,935 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 deepwater access via the Mississippi River. The capital investment as of June 30, 1974, was approximately $158,015,000.

The Slidell Computer Complex, a facility located at Slidell, Louisiana, 20 miles northeast of the Michoud Assembly Facility occupies 14 acres and provides centralized computer services for Michoud, National Space Technology Laboratories, and associated contractors. The Slidell capital investment, as of June 30, 1974, was approximately $25,834,000.

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 June 30, 1974, was $820,203,000.

MISSION

The Marshall Space Flight Center (MSFC) at Huntsville, Alabama became a part of NASA in July 1960. Marshall serves as one of NASA's primary Centers for the design and development of space transportation systems, orbital systems, scientific payloads, and other systems for present and future space exploration. In addition to on-site activities at Huntsville, MSFC manages the Michoud Assembly Facility (MAF) at New Orleans, Louisiana and the Slidell Computer Complex at Slidell, Louisiana.

The Center has major responsibilities for direction and management of the following on-going activities:

1. Space Shuttle Projects:

a. Space Shuttle Main Engine - the high performance, reusable low cost throttleable liquid hydrogen, liquid oxygen fueled rocket engine, for the orbiter vehicle.

b. External Tank - providing the liquid hydrogen/liquid oxygen propellant for the orbiter vehicle during lift-off and to achieve orbital insertion.

c. Solid Rocket Booster - large solid propellant boosters, firing in parallel with the main engine, designed for retrieval, refurbishment and reuse.

d. Integration - participation with the lead Center in assuring that all projects are properly integrated into the overall Space Shuttle Program.

2. The Apollo Soyuz Test Project, including responsibility for providing the Saturn 1B launch vehicle and associated ground support equipment, space vehicle analysis through spacecraft separation, launch and flight operations support, and certain experiments.

3. The High Energy Astronomy Observatory, including technical and program management of an orbital scientific program designed to obtain high quality, high resolution data on cosmic ray, gamma ray, and X-ray sources.

4. The Spacelab, in cooperation with the European Space Research Organization, will provide a versatile and economical laboratory and observatory facility for manned research and applications investigations and experimentation in earth orbit. Spacelab is a pressurized and habitable module which will be carried to and from orbit in the cargo bay of the Space Shuttle.

5. Other projects, such as the Gravitational Redshift (GP-A), a sounding rocket space probe designed for tests related to the equivalence principle of the Einstein Theory of Relativity; and the Laser Geodynamic Satellite (LAGEOS), a passive, solid sphere fitted with retro-reflector cube corners to permit accurate laser ranging from ground-based stations.

The Center has also been assigned the lead role in the study and definition of several additional programs, primarily involving space payload planning and Space Shuttle Utilization. These include the Interim Upper Stage/Space Tug, the Concept Verification Testing Activity (CVT), and the Large Space Telescope.

Marshall is also participating in NASA Earth Resources Survey program activities which are directed generally toward the application of space technology and associated managerial and technical disciplines to solve environmental problems in the surrounding geographic region including Alabama, Tennessee, Kentucky, Missouri, Louisiana, Mississippi, Georgia, and North Carolina.

In addition to these on-going assignments, the Center is deeply involved in a variety of other activities ranging from overall mission analyses of initial Shuttle missions to specific studies within the scientific and applications disciplines, including activities related to laser experiments, gravitational relativity, earth observation, solar power, earth physics, meteoroid studies, space processing, materials science, atmospheric science, magnetospheric physics, space plasma physics, zero-G cloud physics, a solar power residential heating and cooling demonstration project, and other scientific areas within the scope of NASA's mission.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
I. Personnel and Related Costs	$111,632	$106,029	$107,439	$105,900	$27,150
II. Travel.....	1,916	2,233	1,962	2,115	556
III. Facilities Services...	9,215	8,974	9,415	9,601	3,143
IV. Technical Services...	6,722	6,884	6,701	6,919	1,870
V. Administrative Support.....	7,159	5,598	5,799	5,971	1,653
Total, fund requirements	$136,644	$129,718	$131,316	$130,506	$34,372

Over two thirds of Marshall's permanent positions are used in direct support of the various R&D programs. The following table summarizes the actual and planned utilization of positions for direct program activity and for indirect support.

Permanent Positions by Program

Direct Positions	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
Manned Space Flight					
Space shuttle.....	1,291	1,788	1,450	1,523	1,523
Space flight operations.....	1,619	952	1,210	1,106	1,106
Advanced missions.	6	16	9	10	10

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
Space Science					
Physics and astronomy.....	330	388	381	398	398
Launch vehicle procurement.....	32	35	27	60	60
Applications					
Space Applications	114	140	126	114	114
Aeronautics and Space Technology					
Aeronautical research and technology..	14	13	13	13	13
Space and nuclear research and technology.....	60	66	44	44	44
Energy					
Energy Technology Applications....	30	--	44	36	36
Technology Utilization.....	13	13	10	10	10
Subtotal, direct positions.....	3,509	3,411	3,314	3,314	3,314

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Dollars in Thousands)			
Indirect Positions					
Director and staff..	134	111	139	139	139
Administration support.....	786	599	621	621	621
Research and development support.....	71	24	39	39	39
Subtotal, indirect positions.....	991	734	799	799	799
Total, permanent positions.....	4,500	4,145	4,113	4,113	4,113
PERSONNEL AND RELATED COSTS					
I. PERSONNEL AND RELATED COSTS...	$111,632	$106,029	$107,439	$105,900	$27,150
Basis of Fund Requirements					
A. Compensation and Benefits:					
1. Compensation					
a. Permanent positions.	$100,456	$93,529	$95,234	$94,642	$24,137
b. Nonpermanent positions.	1,209	1,411	1,662	1,641	608
c. Reimbursable details...	87	241	36	69	18
d. Overtime and other compensation.	545	643	595	606	151
Subtotal, Compensation.....	$102,297	$95,824	$97,527	$96,958	$24,914
2. Benefits.....	$8,984	$9,805	$9,508	$8,538	$2,135
Subtotal, Compensation and Benefits.	$111,281	$105,629	$107,035	$105,496	$27,049

B. Supporting Costs:

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Dollars in Thousands)			
1. Transfer of Personnel.	$119	$120	$120	$120	$30
2. Personnel Training..	232	280	284	284	71
Subtotal, Supporting Costs.....	$351	$400	$404	$404	$101
Total, Personnel and Related Costs.....	$111,632	$106,029	$107,439	$105,900	$27,150
1. Compensation	$102,297	$95,824	$97,527	$96,958	$24,914
a. Permanent positions	$100,456	$93,529	$95,234	$94,642	$24,137

The difference between the 1975 budget estimate and the 1975 current estimate is the cost of the October 1974 pay raise. This is partially offset by the savings resulting from the reduction in manyears. The decrease in 1976 is attributed to the full year impact of the February 1975 reduction-in-force which more than offsets the full year cost of the pay raise.

Basis of Cost for Permanent Positions

In 1976 the cost of permanent positions will be $94,642,000, a reduction of $592,000 from FY 1975. This reduction is calculated as follows:

Cost of permanent positions in 1975.....		$95,234
Cost Increases:.....		+2,397
Within grade advances and career development		
Full year effect of 1975 actions.....	+$544	
Partial year effect of 1976 actions.....	+499	
Full year effect of October 1974 pay raise....	+996	
Additional extra day.....	+358	

Cost Decreases:		- 2,989
Full year effect of 1975 manpower reduction....	-$2,313	
Turnover savings		
Full year effect of 1975 actions.....	-242	
Partial year effect of 1976 actions.....	-434	
Cost of permanent positions in FY 1976.....		$94,642

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Dollars in Thousands)			
b. Nonpermanent positions					
1. Cost	$1,209	$1,411	$1,662	$1,641	$608
2. Number of manyears	194	224	250	250	92

The 1976 plan includes 250 manyears, which will be used to support the following programs at approximately the levels indicated:

Program	Manyears
College cooperative training.....	108
Vocational cooperative training.....	25
Summer employment.....	20
Youth opportunity.....	76
Other temporary employment.....	21
Total.....	250

The 1975 current estimate is increased from the 1975 budget due to the October 1974 pay raise and an expanded summer and opportunity program with increased emphasis on minority and female hiring efforts. The reduction in the 1976 estimate is attributable to a greater demand for lower salaried clerical employees.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
c. Reimbursable details.....	$87	$241	$36	$69	$18

Reimbursable detailees are assigned to NASA from DOD to support the Center in the field of solid rocket motors and earth resources. This effort provides mutual benefits to NASA and DOD by providing NASA with special talent and by keeping DOD personnel current on the manned space flight technology. The current estimate for 1975 is decreased from the 1975 budget estimate reflecting a reduction of requirements from 20 manyears to 2. The increase in 1976 is due to a full 3-manyear effort in 1976.

d. Overtime and other compensation.....	$545	$643	$595	$606	$151

The current estimate for 1975 is decreased from the 1975 budget estimate as a result of continuing emphasis on reducing overtime costs to the lowest level consistent with mission and statutory requirements. This cost reduction program at MSFC more than offsets a $24 increase due to the October 1974 pay raise. The increase in 1976 is due to the full effect of the October 1974 pay raise.

2. Benefits.....	$8,984	$9,805	$9,508	$8,538	$2,135

The distribution of these costs by major categories is as follows:

Category of Cost					
Contribution to the civil service retirement fund.....	$7,004	$6,631	$6,735	$6,694	$1,718
Contribution for employee life insurance.....	370	361	361	361	91
Contribution for employee health insurance.....	1,232	1,000	1,103	1,196	300
Contribution to FICA.....	21	32	24	25	5
Incentive awards	53	82	84	84	21
Severance pay...	304	1,699	1,201	178	---
Total.....	$8,984	$9,805	$9,508	$8,538	$2,135

The current estimate in 1975 decreased from the 1975 budget estimate due to the lower requirement for severance pay in 1975. This lower requirement was brought about by the success experienced in placing RIF'd employees in other jobs. On June 30, 1974, 108 employees were drawing severance pay, by December 30, 1974, only 31 remained eligible. The decreased requirements for severance pay more than offset the increased health insurance and retirement costs. The decrease in 1976 is due to reduced manyear levels and lower severance pay requirements. The decreased requirements for retirement partially offsets the full year cost of health insurance rate increases in 1976.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
B. Supporting Costs	$351	$400	$404	$404	$101
1. Transfer of personnel.....	119	120	120	120	30

The estimated costs (based on the number and the historical average cost of relocations) provide for certain relocation costs, such as the expenses of selling and buying a home and the movement of household goods. The average cost per move has increased from $3,871 in 1974 to an estimated $4,583 in 1976. Actual 1974 experience was 31 moves; in 1975 this decreases to 28. In 1976, 26 moves are estimated.

2. Personnel training.....	232	280	284	284	71

The personnel training costs are based on the continuation of current training programs and the need to reorient skills of employees into areas compatible with the direction of the space program in the 1970's and MSFC's role in the program. A prime objective is career development to permit employees to advance to more responsible positions and to provide the Center with highly motivated and experienced personnel not readily available in the labor market. The 1975 level remains essentially constant with a slight increase to reflect current training costs. The program for 1976 is planned at the 1975 level.

TRAVEL

II. TRAVEL.....	$1,916	$2,233	$1,962	$2,115	$556

Travel requirements include those for Space Shuttle, Apollo Soyuz Test Project, Spacelab, Space Tug, Large Space Telescope, Solar Electric Propulsion Stage, Concept Verification Testing, Laser Geodynamic Satellite, Environmental and Applications programs and scientific projects such as the High Energy Astronomy Observatory and a Sounding Rocket Space Probe.

The current estimate for 1975 is decreased from the 1975 budget estimate reflecting the recent legislation limiting federal travel expenses. The increase in 1976 reflects an adjustment of the 1975 level to take into account increased air tariffs.

Basis of Fund Requirements

Summary of Travel by Major Category

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Program related travel.....	$1,646	$1,951	$1,821	$1,962	$495
B. Meetings and technical seminars.....	32	11	11	12	4
C. Administrative travel.....	238	271	130	141	57
Total, Travel....	$1,916	$2,233	$1,962	$2,115	$556

FACILITIES SERVICES

III. FACILITIES SERVICES.....	$9,215	$8,974	$9,415	$9,601	$3,143

Basis of Fund Requirements

Summary of Facilities Services

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Maintenance and Related Services					
1. Maintenance, repair and alteration of buildings and grounds.....	$1,767	$1,508	$2,265	$2,055	$ 562
2. Custodial services.....	3,054	2,391	2,379	2,343	725
3. Maintenance of equipment....	499	719	540	564	158
Subtotal.....	$5,320	$4,618	$5,184	$4,962	$1,445
B. Operation of Facilities					
1. Utilities.....	$3,311	$3,702	$3,615	$4,013	$1,446
2. Supplies and equipment....	584	654	616	626	252
Subtotal.....	$3,895	$4,356	$4,231	$4,639	$1,698
Total, Facilities Services.....	$9,215	$8,974	$9,415	$9,601	$3,143
A. Maintenance and Related Services	$5,320	$4,618	$5,184	$4,962	$1,445
1. Maintenance, repair and alterations of buildings and grounds..	$1,767	$1,508	$2,265	$2,055	$562

These services are performed by the U.S. Army Missile Command (AMC) on a reimbursable basis and by the MSFC support services contractor personnel. Over four million square feet of space are involved, of which approximately 11 percent are Army buildings (of considerable age) used and maintained by MSFC. The grounds cover 1,841 acres of which 1,243 acres are improved and 598 acres are unimproved. Maintenance is accomplished by miscellaneous crafts, a mix of some forty building and construction trades.

The current estimate for 1975 is increased from the budget estimate to reflect the need for renovation and repair of the air conditioning systems, a cost not included in the initial 1975 estimate. The decrease of $210 in 1976 results from reduced maintenance, the full year impact of closing facilities and a decrease of 10 manyears in support contractor effort. The reductions based on these three factors are partially offset by wage and price escalation.

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
2. Custodial services....	$3,054	$2,391	$2,379	$2,343	$725

Custodial services are performed principally by support service contractor personnel and include janitorial services for some three million square feet of area in numerous buildings; security services that provide for badging of employees and visitors, maintaining security patrol and policing traffic (the U.S. Army provides perimeter patrol and entrance gate services for which MSFC is charged a pro-rata share); laundry services, comprising the cleaning and laundry of 77,800 pieces of material annually; movement and disposal of approximately 90,000 cubic yards of refuse annually at 132 different pickup points; and fire protection service furnished by the U.S. Army for some 2,553,000 square feet of area.

The decrease in 1976 is attributable to reduced custodial services as a result of the closing of facilities, partially offset by price and wage rate increases.

3. Maintenance of equipment.....	$499	$719	$540	$564	$158

51-423 O - 75 - 46

The current estimate for 1975 is decreased from the 1975 budget estimate to reflect a greater savings being realized through retirement of certain items of equipment and the fact that maintenance costs are running below the amount initially planned. The increase in 1976 reflects price escalation partially offset by a further reduction in the number of equipment units to be maintained.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
B. Operation of Facilities.....	$3,895	$4,356	$4,231	$4,639	$1,698
1. Utilities....	$3,311	$3,702	$3,615	$4,013	$1,446

This item includes the cost of utility services furnished by the U.S. Army Missile Command on a reimbursable basis. Utility services include electricity, steam, water and sewage. Electricity, steam and water usage is metered to the Center. Sewage cost is pro-rated based on on-post population (per capita). The current estimate for 1975 decreased from the 1975 budget estimate to reflect a Center-wide conservation program. The increase in 1976 is attributed solely to cost escalation, approximately 16%, as consumption is expected to decrease as a result of decreased manpower levels. It is estimated that electricity consumption will decrease by 14%; steam, by 6%, and water, by 3%.

2. Supplies and equipment..	$584	$654	$616	$626	$252

The current estimate for 1975 is decreased from the 1975 budget estimate to reflect a deferral of purchases. In examining priorities, it was concluded that this action was necessary to help cover the unexpected air conditioning renovation costs.

TECHNICAL SERVICES

IV. TECHNICAL SERVICES..	$6,722	$6,884	$6,701	$6,919	$1,870

Basis of Fund Requirements

Summary of Technical Services

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Automatic Data Processing					
1. Equipment....	$341	$510	$434	$338	$85
2. Programming and operation services...	4,292	4,429	4,093	4,330	1,163
Subtotal...	$4,633	$4,939	$4,527	$4,668	$1,248
B. Engineering Services.....	$87	$61	$154	$188	$47
C. Scientific and Technical Information and Education Programs					
1. Operation of Redstone scientific and information center.....	$809	$780	$858	$901	$224
2. Educational/ informational programs...	801	705	707	691	206
3. Scientific and technical information.	392	399	455	471	145
Subtotal....	$2,002	$1,884	$2,020	$2,063	$575
Total, Technical Services.....	$6,722	$6,884	$6,701	$6,919	$1,870

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Automatic Data Processing.....	$4,633	$4,939	$4,527	$4,668	$1,248

This line item includes the cost of the support service contract for ADP operations, programming, and systems design. It also includes the cost of lease, maintenance and repair of ADP equipment.

The current estimate for 1975, which is below the 1975 budget estimate, reflects a reduction in programming and operation services, ADP purchases, and a corresponding decrease in support contractor manyears (from 278 to 265). The increase in the 1976 estimate is for higher wage rates; the manyear level decreases further to 261.

B. Engineering Services.....	$87	$61	$154	$188	$47

The current estimate for 1975 was increased from the 1975 budget estimate to reflect the implementation during FY 1975 of the Facility Utilization Study. The cost of this study had not been included in the 1975 budget estimate. The increase in the FY 1976 estimate is attributable to the full year cost of the Facility Utilization Study which will continue throughout the year.

C. Scientific and Technical Information and Educational Programs.....	$2,002	$1,884	$2,020	$2,063	$575

This subfunction covers the cost of the Center's share of the operation of the Redstone Scientific Information Center (RSIC), operated by the U.S. Army Missile Command, on a reimbursable basis and includes 198,000 books and journals, 2,800 periodicals and 400,000 technical papers. It also maintains approximately 1,150,000 documents on microfilm.

The current estimate for 1975 is an increase over the 1975 budget estimate to reflect the increased cost of motion picture supplies and equipment required by the scientific and technical information programs. In addition, the Army has assessed an additional cost on the center to partially absorb unexpected increased costs for RSIC operation.

ADMINISTRATIVE SUPPORT

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
V. ADMINISTRATIVE SUPPORT.....	$7,159	$5,598	$5,799	$5,971	$1,653

Basis of Fund Requirements

Summary of Administrative Support

A. Communications					
1. Leased lines and long distance tolls.....	$597	$585	$611	$602	$162
2. Local telephone service....	725	805	828	775	193
3. Other communications....	108	127	130	128	35
Subtotal.....	$1,430	$1,517	$1,569	$1,505	$390
B. Administrative Printing.....	$298	$440	$347	$340	$85
C. Supplies, Materials and Equipment...	$912	$911	$1,001	$1,033	$366
D. Transportation					
1. Center operations.....	$1,930	$1,240	$1,316	$1,448	$385
2. Common carrier	37	46	35	35	9
Subtotal.....	$1,967	$1,286	$1,351	$1,483	$394

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
E. Administrative Support Services					
1. Installation support services...	$2,140	$1,046	$1,135	$1,194	$318
2. Occupational medicine and environmental health.....	412	398	396	416	100
Subtotal...	$2,552	$1,444	$1,531	$1,610	$418
Total, Administrative Support.....	$7,159	$5,598	$5,799	$5,971	$1,653
A. Communications...	$1,430	$1,517	$1,569	$1,505	$390

In 1974, there was a major reorganization at MSFC resulting in laboratory, office and personnel realignments. As a direct result, the current estimate for 1975 is increased over the 1975 budget estimate to account for rate increases in maintenance, installation, and relocation of telephone instruments. The decrease in 1976 is a result of decreased manpower levels, partially offset by the costs incurred in relocating telephones.

B. Administrative Printing.....	$298	$440	$347	$340	$85

The current estimate for 1975 is decreased from the budget estimate to reflect concerted economy measures directed toward eliminating nonessential printing requirements, purging distribution lists, and terminating obsolete reports. The decrease in 1976 is the full year savings of the economy measures taken in 1975.

C. Supplies Materials and Equipment....	$912	$911	$1,001	$1,033	$366

The current estimate for 1975 is increased over the budget estimate to reflect increased costs of fuels and lubricants. The increase in 1976 is due to price escalation partially offset by savings due to reduced personnel levels and reduced vehicle maintenance levels.

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
D. Transportation...	$1,967	$1,286	$1,351	$1,483	$394

The current estimate for 1975 is increased over the 1975 budget estimate to account for wage and price escalation within the support contract which services the MSFC motor pool. The increase in 1976 includes the full year effect of wage and price increases and the funds to accomplish scheduled maintenance on the NASA #3 aircraft.

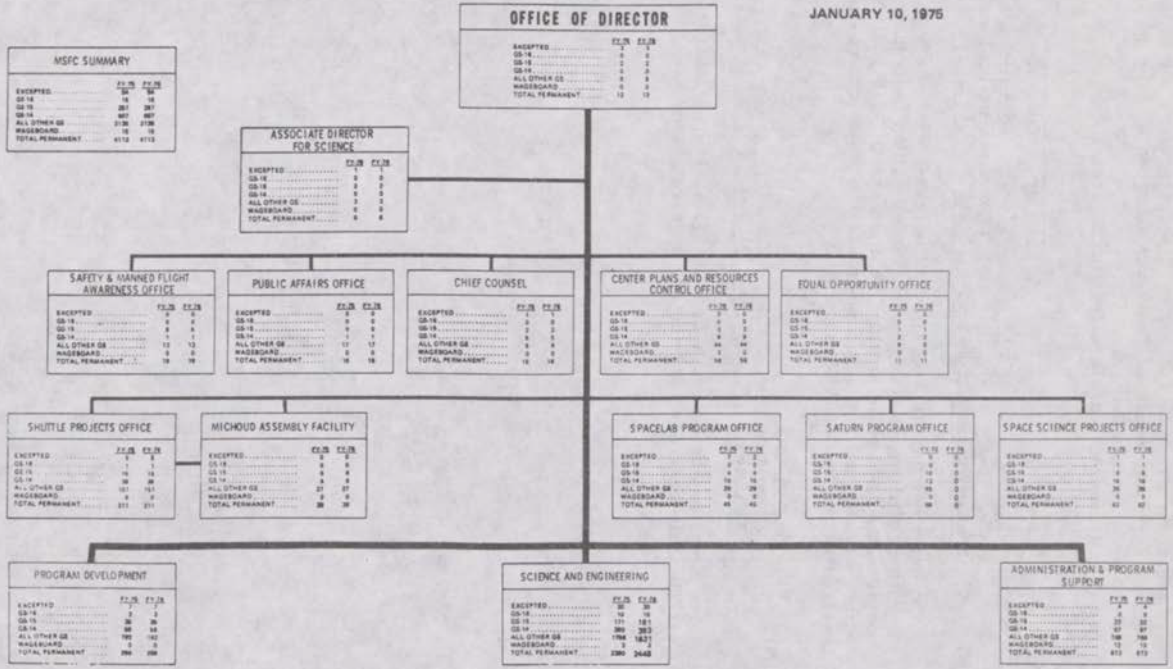
E. Administrative Support Services.....	$2,552	$1,444	$1,531	$1,610	$418

The increases shown, both in the 1975 current estimate and in 1976, are attributable entirely to price and wage rate increases.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

GEORGE C. MARSHALL SPACE FLIGHT CENTER

JANUARY 10, 1975



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724

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1976 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, 7,490 acres are owned by NASA, and 117,837 acres are under restrictive easements. Capital investment for the National Space Technology Laboratories as of June 30, 1974, was approximately $322,902,000. The installation has deepwater access via the Pearl River and the Intracoastal Waterway.

MISSION

The National Space Technology Laboratories (NSTL), formerly the Mississippi Test Facility (MTF), was constructed and operated during the Sixties for acceptance testing of the booster stages of the Saturn V rocket system. The redesignation by NASA of MTF to the new NSTL in June 1974 recognized the emerging role of the installation in space and environmental technology efforts. In addition, NSTL is the prime static test facility for large liquid propellant rocket engines.

The National Space Technology Laboratories will be the site for static testing of the Space Shuttle Main Engine and the Main Propulsion Test Article. In addition to providing Shuttle support, NSTL provides services and facilities for other collocated government agencies engaged in the application of space technology. 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, the State of Louisiana, and the Earth Resources Laboratory, collocated from the Johnson Space Center.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

Functions	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
I. Personnel and Related Costs	$1,532	$1,474	$1,650	$1,672	$418
II. Travel	24	23	23	24	5
Total, fund requirements	$1,556	$1,497	$1,673	$1,696	$423

Distribution of Permanent Postions by Program

The following table summarizes the actual and planned utilization of positions for direct program activity and for indirect support.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Dollars in Thousands)			
Indirect Positions					
Director and staff.....	4	4	4	4	4
Administrative support....	39	39	42	42	42
Research and development support.....	22	22	24	24	24
Total, permanent positions.....	65	65	70	70	70

PERSONNEL AND RELATED COSTS

I. PERSONNEL AND RELATED COSTS.....	$1,532	$1,474	$1,650	$1,672	$418

Basis of Fund Requirements

A. Compensation and Benefits:					
1. Compensation:					
a. Permanent positions....	$1,394	$1,336	$1,493	$1,514	$378
b. Nonpermanent positions....	13	13	16	16	4
c. Overtime and other compensation.....	3	6	6	6	2
Subtotal, Compensation....	$1,410	$1,355	$1,515	$1,536	$384

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
2. Benefits:	$122	$119	$135	$136	$34
Subtotal, Compensation and Benefits.....	$1,532	$1,474	$1,650	$1,672	$418
Total, Personnel and Related Costs.....	$1,532	$1,474	$1,650	$1,672	$418
1. Compensation.....	$1,410	$1,355	$1,515	$1,536	$378
a. Permanent positions	$1,394	$1,336	$1,493	$1,514	$378

The current estimate for 1975 increased from the 1975 budget estimate due to the October 1974 pay raise and an increase of five permanent positions. These positions are required to support the increased activity associated with establishing NSTL as a NASA field installation. The increase in 1976 reflects the normal impact of promotions and within grade advances, the addition of new positions and the abolishment of existing ones, and the full year cost of the October 1974 pay raise.

Basis of Cost for Permanent Positions

In 1976 the cost of permanent positions will be $1,514 an increase of $21 from 1975. The increase is calculated as follows:

Cost of permanent positions in 1975.....		$1,493
Cost increases in 1976.....		+62
Within grade advances and career development		
Full year effect of 1975 actions.....	+$8	
Partial year effect of 1976 actions.....	+7	
Full year effect of 1975 new positions.....	+17	
Full year effect of October 1974 pay raise.....	+24	
Extra day.....	+6	
Cost decreases in 1976.....		-41
Turnover savings		
Full year effect of 1975 actions.....	-$33	
Partial year effect of 1976 actions.....	-8	
Cost of permanent positions in 1976.....		$1,514

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Dollars in Thousands)			
b. Nonpermanent Positions					
1. Cost.....	$13	$13	$16	$16	$5
2. Manyears.....	2	2	2	2	---

The 1976 estimate will support 2 manyears for the College Cooperative Training Program.

The current estimate for 1975 is increased from the 1975 budget estimate as a result of two career development promotions not provided for in the 1975 budget. In addition, the current estimate includes the cost of the October 1974 pay raise. The 1976 estimate continues at the 1975 level.

c. Overtime and other compensation...	$3	$6	$6	$6	$2

The 1976 funds cover overtime only and are necessary to meet management and other administrative requirements in areas such as procurement and financial management.

2. Benefits.....	$122	$119	$135	$136	$34

The following table indicates the costs of Personnel Benefits by the major categories:

Category of Cost					
Contribution to Civil Service Retirement Fund.....	$99	$95	$106	$107	$27
Contribution for employee life insurance.....	5	4	6	6	2
Contribution for employee health insurance.....	18	18	22	22	5
Incentive awards....	---	2	1	1	---
Total.....	$122	$119	$135	$136	$34

The current estimate for 1975 is increased from the 1975 budget estimate as a result of the five additional positions and the October 1974 pay raise.

TRAVEL

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
II. TRAVEL.....	$24,000	$23,000	$23,000	$24,000	$5,000

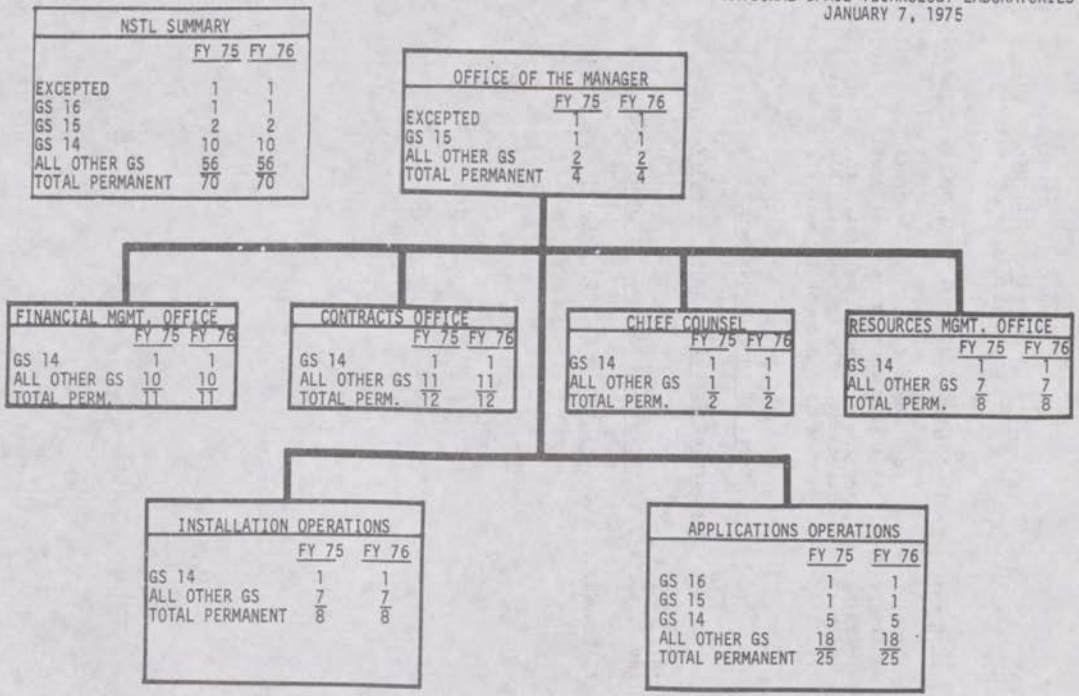
Travel requirements are associated with the operation and maintenance of the facility, committee assignments, management meetings, project support to other NASA centers, and administrative matters such as legal, contracting, finance and resources management. The increase in 1976 reflects an adjustment to the 1975 level to take into account increased air fares.

Basis of Fund Requirements

Summary of Travel by Major Category

A. Administrative travel.....	$24,000	$23,000	$23,000	$24,000	$5,000
Total Travel.....	$24,000	$23,000	$23,000	$24,000	$5,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NATIONAL SPACE TECHNOLOGY LABORATORIES
JANUARY 7, 1975



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RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1976 ESTIMATES

GODDARD SPACE FLIGHT CENTER

DESCRIPTION

The Goddard Space Flight Center, located 15 miles northeast of Washington D.C., at Greenbelt, Maryland, is situated on a 554-acre main site. Three additional nearby plots of 620 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 fixed assets in progress and contractor-held facilities at various locations as of June 30, 1974 was $724,257,000 (including capital type facilities of the Spaceflight Tracking and Data Network and other supporting activities including equipment aboard ships and aircraft).

MISSION

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 of experimentation in space science and applications. The Goddard Center has developed many diverse capabilities: the management of complex satellite 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 scientific experiments flown in satellites.

The majority of the Goddard Center's personnel are located at Greenbelt, Md.; 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.

Goddard is responsible for the management of applications satellite projects, such as the Synchronous Meteorological Satellite (SMS), Television Infra-Red Observation Satellite (TIROS), Applications Explorer Missions (AEM), Nimbus, Earth Resources Technology Satellites (LANDSAT), Applications Technology Satellites (ATS); management of scientific satellite projects which include the Orbiting Solar Observatory (OSO), the Atmosphere Explorers (AE) and the small Explorer series; project management of the Delta launch vehicle; management and operation of the would-wide Spaceflight Tracking and Data Network

(STDN) and NASA Communications Network (NASCOM); and the Center carries out an extensive scientific and meteoroligical sounding rocket program.

Major Goddard activities during the year were in the following areas:

Applications Satellites - Goddard is presently involved with several key applications satellite projects: the Synchronous Meteorological Satellite (SMS), the Earth Resources Technology Satellite (LANDSAT), and the Applications Technology Satellite (ATS). The SMS-1 launched in May 1974, along with SMS-B, will provide continuous weather coverage from a geostationary orbit. The Earth Resources Technology Satellite is presently providing high quality images of the earth and aiding in a wide variety of earth resource disciplines. The ATS-6 launched in May 1974, is a highly flexible spacecraft carrying advanced meteorological, communications, air traffic control, and scientific experiments. Tiros-N will provide improved measurements of the earth's surface and its atmosphere for meteorological and environmental monitoring purposes.

Nimbus-5, now in orbit, provides additional data from instruments designed to help in weather analysis and prediction. Nimbus-F will provide basic data to assess the role of incoming solar radiation on large-scale weather systems. Nimbus-G will provide air pollution and oceanographic data on a global basis.

Scientific Satellites - During the past year Goddard managed scientific satellites have continued to probe the complex nature of our solar system and the universe. Explorer 50 (IMP J), launched in October 1973, continues the investigation of the interplanetary magnetic field and the magnetosphere that surrounds the earth. Atmospheric Explorer (AE-C), launched in December 1973, provides a satellite platform that is suitable for coordinated study of the thermosphere. Radio Astronomy Explorer B, launched in June 1973, continues to make measurements of galactic and solar radio noise at frequencies below ionospheric cutoffs and external to terrestrial background interference by utilization of the moon for occulation, focusing, or aperture blocking for increased resolution and discrimination. Work is underway on several other spacecraft which will result in launchings in the next year, including OSO-I, AE-D&E, and SAS-C.

International Programs - Goddard continues in its responsibility to carry out international cooperative efforts in space exploration. Technical assistance and launch support were provided for the German AEROS-2, Netherlands ANS satellites, United Kingdom UK-5 and Italian San Marco C-2. All were launched aboard NASA Scout rockets during 1974. The German built Helios Satellite containing three Goddard experiments was launched in December 1974 and is being tracked by NASA. Several other cooperative programs with Canada and Great Britain will result in spacecraft launchings within the next several years. Work is also underway on two major programs, International Sun/Earth Explorer (ISEE) and International Ultraviolet Explorer (IUE). ISEE will use three satellites (2 NASA, 1 ESRO) to conduct plasma and particle studies of the earth's magnetosphere. IUE will be used by both the United

States and foreign experimentors to sutdy the spectra of the stars.

Tracking and Data Acquisition - The Goddard-managed Spaceflight Tracking and Data Network (STDN) provides tracking and communications coverage for NASA's manned and unmanned satellites in earth orbit and at lunar distance. The network supports an average of approximately 40 spacecraft. Significant effort will be applied by the network in support of the Apollo Soyuz Test Project (ASTP).

Sounding Rockets - During 1974 more than 50 sounding rocket launchings, primarily from Wallops Island, Virginia, were conducted by Goddard bringing to over 1600 the number of sounding rocket launchings in the program since 1959.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

			1975			
		1974	Budget Estimate	Current Estimate	1976	Transition Period
			(Thousands of Dollars)			
I.	Personnel.....	$81,990	$84,178	$87,099	$87,630	$22,861
II.	Travel.....	2,249	2,245	2,274	2,255	631
III.	Facilities Services	5,839	7,421	8,460	9,194	2,474
IV.	Technical Services.	2,445	1,882	1,791	1,914	508
V.	Administrative Support.....	4,958	4,853	5,209	4,854	1,266
	Total, fund requirements	$97,481	$100,579	$104,833	$105,847	$27,740

Distribution of Permanent Positions by Program

Over two-thirds of Goddard's permanent positions are used in direct support of the various R&D programs. The following table summarizes the actual and planned utilization of positions for direct program activity and for indirect support.

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	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
Direct Positions					
Manned Space Flight					
Space shuttle.....	5	2	6	7	7
Space flight operations	25	19	22	17	17
Apollo.....	---	1	---	---	---
Space Science					
Physics and astronomy..	1,036	1,106	1,039	987	987
Lunar and planetary exploration.....	140	145	150	140	140
Launch vehicle procurement.....	50	56	58	60	60
Applications					
Space Applications.....	697	611	654	673	673
Aeronautics and Space Technology					
Space and nuclear research and technology.....	64	74	80	105	105
Tracking and Data Acquisition.....	673	676	686	706	706
Technology Utilization...	7	7	7	7	7
Subtotal, Direct Positions.....	2,697	2,697	2,702	2,702	2,702
Indirect Positions					
Director and staff.....	16	16	17	17	17
Administrative support.	836	837	778	778	778
Research and development support.....	259	258	257	257	257
Subtotal, Indirect Positions.....	1,111	1,111	1,052	1,052	1,052
Total, Permanent Positions	3,808	3,808	3,754	3,754	3,754

PERSONNEL AND RELATED COSTS

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
I. PERSONNEL AND RELATED COSTS.....	$81,990	$84,178	$87,099	$87,630	$22,861
Basis of Fund Requirements					
A. Compensation and Benefits:					
1. Compensation:					
a. Permanent positions..	$74,063	$75,762	$78,350	$78,541	$20,426
b. Nonpermanent positions..	482	577	789	825	338
c. Overtime and other compensation..	545	606	589	601	150
Subtotal, Compensation..	$75,090	$76,945	$79,728	$79,967	$20,914
2. Benefits:.....	$6,497	$6,555	$6,898	$7,187	$1,828
Subtotal, Compensation and Benefits...	$81,587	$83,500	$86,626	$87,154	$22,742
B. Supporting Costs:					
1. Transfer of personnel.....	$44	$118	$69	$69	$17
2. Personnel training	359	560	404	407	102
Subtotal, Supporting Costs..	$403	$678	$473	$476	$119
Total, Personnel and Related Costs.....	$81,990	$84,178	$87,099	$87,630	$22,861
1. Compensation.....	$75,090	$76,945	$79,728	$79,967	$20,914
a. Permanent positions..	$74,063	$75,762	$78,350	$78,541	$20,426

The current estimate for 1975 is increased over the 1975 budget estimate due to the October 1974 pay raise which is partially offset by savings resulting from the manpower reduction from 3,808 positions to 3,754.

The increase in 1976 reflects the full year net cost of these actions.

Basis of Cost for Permanent Positions

In 1976 the cost of permanent positions will be $78,541 an increase of $191 from 1975. This increase results as follows:

Cost of permanent positions in 1975.....		$78,350
Cost Increases:.....		+3,130
Within Grade advances and career development		
Full year effect of 1975 actions.....	+$681	
Partial year effect of 1976 actions.....	+966	
Full year effect of October 1974 pay raise..	+1,150	
Additional extra day.....	+333	
Cost Decreases.....		-2,939
Full year effect of 1975 manpower reductions	-$434	
Turnover savings		
Full year effect of 1975 actions.....	-1,032	
Partial year effect of 1976 actions.....	-1,473	
Cost of permanent positions in 1976.....		$78,541

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
b. Nonpermanent positions:					
1. Cost.....	$482	$577	$789	$825	$338
2. Number of manyears..	80	96	114	116	48

The 1976 estimate will support the following programs at approximately the levels indicated below:

Distribution of Nonpermanent Manyears by Program

College cooperative training	31
Summer employment	19
Opportunity programs	51
Other temporary employment	15
Total	116

The current estimate for 1975 is increased from the 1975 budget estimate to reflect the cost of the October pay raise and an increase in opportunity programs, primarily for the establishment of a worker trainee program, which provides full time on the job training to disadvantaged high school graduates. The 1976 estimate reflects the full year cost of these actions at essentially the same level of program as 1975.

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)				
c. Overtime and other compemsation	$545	$606	$589	$601	$150

Overtime at Goddard is required to meet peak operational requirements usually culminating in the launch of a manned or automated spacecraft. Some of the areas most heavily utilizing overtime are fabrication, experimentation testing, and launching and tracking of the spacecraft. The current estimate for 1975 is reduced from the 1975 budget estimate due to a reassessment of overtime requirements based on 1974 experience and the estimated workload. The savings from this are partially offset by the cost of the October 1974 pay raise. The increase in 1976 reflects the full year cost of the pay raise.

2. Benefits	$6,497	$6,555	$6,898	$7,187	$1,828

The following table indicates the cost of personnel benefits for each major category:

Category of Cost					
Contribution to the Civil Service Retirement Fund	$5,136	$5,302	$5,497	$5,511	$1,432
Contribution for employee life insurance	259	278	274	275	71

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Contribution for employee health insurance.....	869	890	1,056	1,331	302
Constribution to FICA.....	16	20	26	27	11
Incentive awards...	38	35	35	35	10
Other personnel benefits.....	10	30	10	8	2
Severance pay.....	169	---	---	---	---
Total.....	$6,497	$6,555	$6,898	$7,187	$1,828

The current estimate for 1975 is increased from the 1975 budget estimate due to the higher cost of health insurance and the 20% increase in the government share of employee health premiums, effective in January 1975. The increase in 1976 reflects the full year cost of these increases.

B. Supporting Costs	$403	$678	$473	$476	$119

Supporting personnel costs provide for the expense of moving employees to their intial duty station or reassignment and for maintaining and expanding the skill of our employees. These costs are summarized as follows:

1. Transfer of personnel.....	$44	$118	$69	$69	$17

The current estimate for 1975 is decreased from the 1975 budget estimate due to the reduction in the level of hiring activity resulting from the reduced manpower levels. The estimate for 1976 provides for 46 moves, the same as currently estimated for 1975.

2. Personnel training	$359	$560	$404	$407	$102

The current estimate for 1975 is decreased from the 1975 budget estimate due to cancellation of a planned series of courses to conserve funds to meet requirements in other areas. The increase in 1976 is due to higher tuition rates.

TRAVEL

II. TRAVEL.....	$2,249	$2,245	$2,274	$2,255	$631

Approximately 85% of Goddard's travel funds support the Center's research and development programs. Goddard has approximately 200 active research and

development contracts in excess of $100,000. Technical officers are required to review contractors' performance at design reviews, fabrication, and during integration and test of the spacecraft. As projects reach the flight stage, support is required for pre-launch and post-launch activities. In addition to flight project management, Goddard responsibilities in the tracking and data acquisition effort necessitate travel to the stations in the world-wide tracking and data network for instrumentation of the sites and inspection prior to launch.

The current estimate for 1975 is increased from the 1975 budget estimates to reflect travel requirements to support the agency's "Outlook for Space" planning effort. This is partially offset by the effect of the recent legislation limiting federal travel expenses. Travel requirements for 1976 are estimated at the 1975 level, excluding "Outlook for Space" study which phases out at the end of 1975, and adjusted to take into account increased air tariffs.

Basis of Fund Requirements

Summary of Travel by Major Category

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Program related travel.....	$1,816	$1,896	$1,965	$1,919	$541
B. Meeting and technical seminars.....	320	238	216	235	63
C. Administrative travel.....	113	111	93	101	27
Total Travel.....	$2,249	$2,245	$2,274	$2,255	$631

FACILITIES SERVICES

III. FACILITIES SERVICES..	$5,839	$7,421	$8,460	$9,194	$2,474

Basis of Fund Requirements

Summary of Facilities Services

A. Rental of Real Property.....	$92	$1,401	$1,290	$1,266	$286

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
B. Maintenance and Related Services					
1. Maintenance, repair, alterations of buildings and grounds.....	$844	$877	$856	$1,065	$278
2. Maintenance of equipment.....	220	350	226	275	83
3. Custodial services	1,384	1,401	1,281	1,417	372
Subtotal.....	$2,448	$2,628	$2,363	$2,757	$733
C. Operation of Facilities					
1. Utilities.....	$2,443	$2,619	$3,741	$4,145	$1,086
2. Supplies and equipment.....	856	773	1,066	1,026	369
Subtotal.....	$3,299	$3,392	$4,807	$5,171	$1,455
Total, Facilities Services	$5,839	$7,421	$8,460	$9,194	$2,474
A. Rental of Real Property.....	$92	$1,401	$1,290	$1,266	$286

The current estimate for 1975 is decreased from the 1975 budget estimate to reflect a 13% reduction in the GSA rates for property rentals.

B. Maintenance and Related Services	$2,448	$2,628	$2,363	$2,757	$733
1. Maintenance, repair and alterations of buildings and grounds.....	$844	$877	$856	$1,065	$278

This covers 35 buildings comprising 2.5 million square feet, 1,092 acres of ground, 489 acres of surfaced areas, and utility systems. The current estimate for 1975 is reduced from the 1975 budget estimate to reflect the deferral of maintenance activity to conserve funds required to cover utility

rate increases. The 1976 estimate provides for increased preventive maintenance services which have been deferred from previous years due to funding constraints.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
2. Maintenance of equipment.....	$220	$350	$226	$275	$83

The current estimate for 1975 is reduced from the 1975 budget estimate due to purchase, in 1974, of new equipment which is under warranty for most of 1975. The 1976 increase reflects the requirement to maintain this equipment plus increases in other equipment maintenance contract prices.

3. Custodial services	$1,384	$1,401	$1,281	$1,417	$372

The current estimate for 1975 is reduced from the 1975 budget estimate to reflect a revision to the janitorial support contract funding plan. The increase in 1976 provides for wage increases for both the janitorial and guard service contracts, with no increase in the level of support.

C. Operation of Facilities	$3,299	$3,392	$4,807	$5,171	$1,455
1. Utilities.....	$2,443	$2,619	$3,741	$4,145	$1,086

The current estimate for 1975 is increased from the 1975 budget estimate, due to a 65% rise in electric power rates, which is partically offset by a 16% reduction in consumption. The 1976 estimate provides for the full year cost of the 1975 rate increase with no increase in consumption.

2. Supplies and materials.....	$856	$773	$1,066	$1,026	$369

The current estimate for 1975 is increased from the 1975 budget estimate due primarily to higher prices for fuel oil and building materials. The 1976 estimate provides for an essentially level procurement activity with a small reduction in requirements for building materials.

TECHNICAL SERVICES

IV. TECHNICAL SERVICES...	$2,445	$1,882	$1,791	$1,914	$508

Basis of Fund Requirements

Summary of Technical Services

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Automatic Data Processing					
1. Equipment.....	$929	$437	$219	$237	$66
2. Programming and operations.....	634	730	881	875	224
Subtotal.....	$1,563	$1,167	$1,100	$1,112	$290
B. Engineering Services.	$75	$51	$80	$89	$21
C. Scientific and Technical Information and Educational Programs					
1. Operation of technical libraries.....	$371	$375	$317	$357	$100
2. Educational/ informational programs.....	300	156	184	227	65
3. Scientific and technical information.....	136	133	110	129	32
Subtotal.....	$807	$664	$611	$713	$197
Total, Technical Services	$2,445	$1,882	$1,791	$1,914	$508
A. Automatic Data Processing.....	$1,563	$1,167	$1,100	$1,112	$290

The current estimate for 1975 is reduced from the 1975 budget estimate due to the decision to forego procurement of additional computer capability to allow reprogramming of funds required to cover the utility rate increases. The 1976 estimate reflects continuation of the 1975 level of services.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
B. Engineering Services.	$75	$51	$80	$89	$21

The current estimate for 1975 is increased above the 1975 budget estimate to provide for design and drafting services in support of facility alteration and modification projects required to implement the recent organizational realignments at the center. The 1976 estimate provides for continuation of this activity with adjustment for contractor wage increases.

C. Scientific and Technical Information and Educational Programs	$807	$664	$611	$713	$197
1. Operation of technical libraries.....	$371	$375	$317	$357	$100

The library collection includes over 45,000 books, 37,000 volumes of bound journals and 1,800 current journals, plus 900,000 microfiche copies of aerospace documents. Negotiation of a new library operation contract for 1975 resulted in decreased cost for services while maintaining the same level of effort as estimated in the 1975 budget. The increase in 1976 is due to higher contractor wage rates, with no increase in the level of effort.

2. Educational/ information programs.....	$300	$156	$184	$227	$65

The current estimate for 1975 is increased from the budget estimate to initiate expansion of the visitors center in preparation for the Nation's bicentennial celebration.

The 1976 estimate provides primarily for completion of the visitors center expansion and the operation of the center during the first six months of the bicentennial.

3. Scientific and technical information....	$136	$133	$110	$129	$32

The current estimate for 1975 is reduced from the 1975 budget estimate to allow funding of utility rate increases. The 1976 estimate allows partial return to the normal level of funding to support this activity.

ADMINISTRATIVE SUPPORT

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
V. ADMINISTRATIVE SUPPORT.....	$4,958	$4,853	$5,209	$4,854	$1,266

Basis of Fund Requirements

Summary of Administrative Support

A. Communications					
1. Leased lines and long distance tolls.....	$746	$794	$824	$829	$212
2. Local telephone service.....	950	1,020	973	983	257
3. Other communications.....	13	14	13	14	4
Subtotal.....	$1,709	$1,828	$1,810	$1,826	$473
B. Administrative Printing and Reproduction.....	$161	$130	$130	$107	$30
C. Supplies, Materials, and Equipment.....	$1,053	$889	$950	$895	$231
D. Transportation					
1. Center operations	$1,394	$1,402	$1,400	$1,391	$365
2. Common carrier...	26	18	18	19	---
Subtotal.....	$1,420	$1,420	$1,418	$1,410	$365
E. Administrative Support Services					
1. Installation support services..	$329	$278	$605	$285	$80

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
2. Occupational medicine and environmental health.....	$286	$308	$296	$331	$87
Subtotal.....	$615	$586	$901	$616	$167
Total, Administrative Services.....	$4,958	$4,853	$5,209	$4,854	$1,266
A. Communications.....	$1,709	$1,828	$1,810	$1,826	$473

The current estimate for 1975 is reduced from the 1975 budget estimate to reflect a reduction in Goddard's share of the cost of the Federal Telecommunications Service (FTS) lines. This is partially offset by the higher cost of leased lines. The increase in 1976 provides for higher FTS rates, and the full year cost of the leased lines.

B. Administrative Printing and Reproduction.....	$161	$130	$130	$107	$30

The 1976 decrease reflects the center's continuing reduction in the level of contract printing and reproduction services to help offset severe cost increases in other areas.

C. Supplies, Materials and Equipment.....	$1,053	$889	$950	$895	$231

The current estimate for 1975 is increased from the 1975 budget estimate to reflect higher prices for office supplies, primarily paper products, and the decision to purchase previously leased equipment, for which a lease/purchase analysis indicated economies would be achieved through purchase. The decrease in 1976 reflects the savings in lease costs resulting from this action.

D. Transportation.....	$1,420	$1,420	$1,418	$1,410	$365

These funds provide primarily for the on-site transportation and warehousing contractor, whose level of support remains essentially constant from year to year.

E. Administrative Support Services.....	$615	$586	$901	$616	$167

The current estimate for 1975 is increased from the 1975 budget estimate to provide contract support for the agency's "Outlook for Space" planning effort. The 1976 estimates reflect a return in the previous level of activity, excluding "Outlook" which is scheduled to be completed by the end of 1975.

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1976 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 only 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, totaling 6,561 acres, consists of 2,313 acres on the main base; 3,000 acres on Wallops Island; 108 acres on the mainland tracking site; and 1,140 acres of unusable marsh land. The total capital investment, including fixed assets in progress and contractor-held facilities at various locations, as of June 30, 1974 was $125,334,000.

MISSION

Wallops Flight Center is responsible for planning and conducting applied research and development with emphasis on scientific payload development, instrumentation, facilities and techniques, aeronautical and terminal area research projects and ecological studies.

Wallops Flight Center prepares, assembles, launches, tracks and acquires scientific information from space vehicles. 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 and manage NASA research projects.

Research at Wallops Flight Center is directed toward gathering information about the earth's atmosphere and its near space environment. The Center utilizes launch vehicles ranging in size from the small Arcas and Hasp meteorological rockets to the 72-foot Scout rocket with orbital capability in obtaining scientific data about the atmosphere and the near space environment. Sixteen satellites have been launched. Wallops Flight Center has launched approximately 8,000 research vehicles consisting of from one to seven stages in the quest for scientific knowledge.

Wallops facilities are utilized for many other research projects, such as space component tests, helicopter and aircraft drop tests, helicopter and aircraft noise projects, anti-skid tests on grooved runways, V/STOL terminal air research, collision avoidance programs, and laser and radar tracking of aircraft and satellites.

Wallops Flight Center exercises project management responsibility for several NASA sponsored projects such as GEOS-C, the Experimental Inter-American Meteorological Rocket Network (EXAMETNET), operation of remote site launching and tracking facilities, and operation of NASA's portable range facilities for sounding rockets.

The Center is also responsible for a portion of the National Sounding Rocket Program. This requires interface with the scientific, university and international community; engineering support including analytical, feasibility, and design studies, payload, vehicles and recovery system engineering, test and evaluation; and data analysis and reporting.

A portion of the Center's effort is devoted to NASA's program of international cooperation in space research. Foreign countries are provided with training programs for their personnel, assistance in activation of launch sites, and with technical assistance and advice in launching experiments and in operation of their ranges. Representatives of foreign countries have visited Wallops Flight Center to observe operations or seek assistance in establishing sounding rocket facilities of their own.

Wallops Flight Center is involved in the applications of remote sensing from aircraft and space platforms in the Chesapeake Bay area. As part of the program, the Center is working closely with user groups to develop remote sensing analysis and monitoring techniques for studying the ecology of the area.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

Functions	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
I. Personnel and Related Costs.....	$7,784	$8,037	$8,278	$8,527	$2,197
II. Travel.....	234	265	237	251	123
III. Facilities Services.	2,651	2,413	2,654	2,920	877
IV. Technical Services..	193	227	248	274	17
V. Administrative Support.....	626	762	683	733	329
Total, fund requirements.....	$11,488	$11,704	$12,100	$12,705	$3,543

Distribution of Permanent Positions by Program

The following table summarizes the actual and planned utilization of positions for direct program activity and for indirect support.

Direct Positions

Manned Space Flight					
Space flight operations..	2	5	1	1	1
Space Science					
Physics and astronomy....	66	83	67	63	63
Lunar and planetary exploration.....	2	2	1	1	1
Launch vehicle procurement.....	3	3	3	3	3

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
Direct Positions (Cont'd)					
Space Applications.....	62	62	58	63	63
Aeronautics and Space Technology					
Aeronautical research and technology.....	18	36	19	18	18
Space and nuclear research and technology.....	1	2	2	2	2
Tracking and Data Acquisition.....	99	53	99	99	99
Subtotal, direct positions.....	253	246	250	250	250
Indirect Positions					
Director and staff.....	6	4	6	6	6
Administrative support....	72	69	72	72	72
Research and development support.....	89	101	87	87	87
Subtotal, indirect positions.....	167	174	165	165	165
Total, permanent positions.	420	420	415	415	415
PERSONNEL AND RELATED COSTS					
I. PERSONNEL AND RELATED COSTS	$7,784	$8,037	$8,278	$8,527	$2,197

51-423 O - 75 - 48

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Basis of Fund Requirements					
A. Compensation and Benefits					
1. Compensation					
a. Permanent positions...	$6,856	$7,050	$7,233	$7,411	$1,902
b. Nonpermanent positions...	112	140	189	206	60
c. Overtime and other compensation...	146	112	115	118	32
Subtotal, Compensation...	$7,114	$7,302	$7,537	$7,735	$1,994
2. Benefits.....	627	654	695	731	188
Subtotal, Compensation and Benefits	$7,741	$7,956	$8,232	$8,466	$2,182
B. Supporting Costs					
1. Transfer of personnel.....	$5	$6	$6	$6	---
2. Personnel training.....	38	75	40	55	15
Subtotal, Supporting Costs....	$43	$81	$46	$61	$15
Total, Personnel and Related Costs.....	$7,784	$8,037	$8,278	$8,527	$2,197
1. Compensation.....	$7,114	$7,302	$7,537	$7,735	$1,994
a. Permanent positions.....	$6,856	$7,050	$7,233	$7,411	$1,902

The current estimate for 1975 is increased from the 1975 budget estimate due to the October 1974 pay raise. This is partially offset by the savings resulting from the reduction in manpower from 420 to 415.

The increase in 1976 reflects the full year net effect of these actions.

Basis of Cost for Permanant Positions
(Thousands of Dollars)

In 1976 the cost of permanent positions will be $7,411, an increase of $178 from 1975. This increase is calculated as follows:

Cost of permanent positions in 1975		$7,233
Cost increases in 1976:		+311
Within grade advances and career development		
Full year effect of 1975 actions	+$96	
Partial year effect of 1976 action	+89	
Full year effect of October 1974 pay raise	+$98	
Additional extra day	+28	
Cost decreases in 1976:		-133
Abolished positions and turnover savings		
Full year effect of 1975 actions	-$88	
Partial year effect of 1976 actions	-45	
Cost of permanent positions in 1976		$7,411

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Dollars in Thousands)			
b. Nonpermanent positions					
1. Cost	$112	$140	$189	$206	$60
2. Number of manyears	20	24	31	33	10

The 1976 estimate will support the following programs at approximately the levels indicated below:

Distribution of Nonpermanent Manyears by Program

Program	Manyears
College Cooperative Training	14
Summer employment	3
Opportunity Programs	14
Other temporary employment	2
Total	33

The current estimate for 1975 is increased from the 1975 budget estimate to reflect the cost of the October 1974 pay raise and the establishment of a Worker Trainee Opportunity program which provides full time on the job training to promising high school graduates. The 1976 estimate reflects the full year cost of these actions at essentially the same level of program as 1975.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
c. Overtime and other compensation	$146	$112	$115	$118	$32

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 the normal hours to operate the launch facilities, provide instrumentation support, and conduct tracking and data acquisition activities required to assure mission success.

The current estimate for 1975 is increased over the 1975 budget estimate to allow for the October 1974 pay raise. The increase in 1976 reflects the full year cost of the pay raise.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
2. Benefits	$627	$654	$695	$731	$188

The following table indicates the cost of personnel benefits by the major categories:

Category of Cost					
Contribution to the Civil Service Retirement Fund	$483	$500	$511	$524	$134
Contribution for employees life insurance	26	35	29	30	8
Contribution for employees health insurance	113	104	144	165	42
FICA	3	8	8	9	2
Incentive awards	---	5	1	1	1
Other benefits	2	2	2	2	1
Total	$627	$654	$695	$731	$188

The current estimate for 1975 is increased over the budget estimate to account for the higher cost of health insurance premiums and a 20% increase in the government contribution to the Federal Health Benefits Program, effective in January 1975. The increase in 1976 reflects the full year cost of these actions.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
B. Supporting Costs.....	$43	$81	$46	$61	$15
1. Transfer of personnel.....	$5	$6	$6	$6	---

The estimates for 1975 and 1976 provide for a continuation at the 1974 level. Most recent experience indicates that on the average one move per year occurs.

2. Personnel training.....	$38	$75	$40	$55	$15

The current estimate for 1975 is reduced from the 1975 budget estimate based on 1974 experience. The 1976 estimate is increased to account for the transfer of previously on-site courses, conducted by the University of Virginia to their new campus, where tuition rates are much higher.

TRAVEL

II. TRAVEL.....	$234	$265	$237	$251	$123

The amount requested for 1976 provides for approximately 1,100 trips to locations throughout the United States and other countries in support of the Center's programs. Sounding rockets, SEASAT, GEOS-C, and Earth Resources projects account for most of the trips in this country. Travel to foreign countries in support of launches and to tracking sites is required for the projects listed below.

International Cooperative Meteorological Program - trips to New Zealand, Brazil, England, France, and Spain.

Sounding Rocket Support - trips to Kerguelen, France, Peru, and Ft. Churchill, Canada

San Marco Support - trips to Italy, and Kenya, Africa

The current estimate for 1975 is reduced from the 1975 budget estimate to reflect the recently enacted legislation reducing federal travel expenses. Travel requirements for 1976 are estimated at the 1975 level and adjusted to account for increased air fares.

Basis of Fund Requirements

Summary of Travel by Major Category

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Program related travel.....	$100	$141	$123	$131	$35
B. Meetings and technical seminars.....	20	18	16	17	4
C. Administrative travel.....	114	106	98	103	84
Total Travel.....	$234	$265	$237	$251	$123

FACILITIES SERVICES

III. FACILITIES SERVICES...	$2,651	$2,413	$2,654	$2,920	$877

Basis of Fund Requirements

Summary of Facilities Services

A. Maintenance and Related Services					
1. Maintenance, repair and alterations of buildings and grounds.....	$565	$566	$550	$615	$48
2. Custodial services..	757	720	742	809	191
3. Maintenance and equipment.....	178	180	180	192	147
Subtotal.....	$1,500	$1,466	$1,472	$1,616	$386

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
B. Operation of Facilities					
1. Utilities.....	$400	$331	$574	$645	$382
2. Supplies and equipment.....	751	616	608	659	109
Subtotal.....	$1,151	$947	$1,182	$1,304	$491
Total, Facilities Services..	$2,651	$2,413	$2,654	$2,920	$877
A. Maintenance and Related Services.....	$1,500	$1,466	$1,472	$1,616	$386
1. Maintenance, repair and alterations of buildings and grounds.....	$565	$566	$550	$615	$48

Over 330 buildings and approximately one million square feet of building space on 6,561 acres must be maintained. 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 current estimate for 1975 is decreased from the 1975 budget estimate to reflect a deferral of maintenance. In examining priorities it was concluded that this action was necessary to allow the use of these funds to cover the increasing cost of utilities. The increase in 1976 provides for a return to the normal level of maintenance activity taking into account the cost of wage and price increases.

2. Custodial services.....	$757	$720	$742	$809	$191

The current estimate for 1975 is increased from the 1975 budget estimate to reflect wage increases in the supply management support contract renegotiated during 1975. The 1976 increase reflects the full year cost of this contract increase.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
3. Maintenance of equipment.....	$178	$180	$180	$192	$147

The increase in 1976 reflects wage increases for the heating plant maintenance and operations support contractor.

B. Operation of Facilities.....	$1,151	$947	$1,182	$1,304	$491
1. Utilities.....	$400	$331	$574	$645	$382

The current estimates for 1975 and 1976 reflect the same level of usage as experienced in 1974. The increase in the current estimate for 1975 from the 1975 budget estimate is necessary to cover a 43% increase in electric power rates. The increase in 1976 reflects further rate escalation.

2. Supplies and equipment.....	$751	$616	$608	$659	$109

The current estimate for 1975 is reduced from the 1975 budget estimate due to the purchase, late in 1974, of equipment originally planned for purchase in 1975. The increase in 1976 reflects higher supply and equipment prices.

TECHNICAL SERVICES

IV. TECHNICAL SERVICES.....	$193	$227	$248	$274	$17

Basis of Fund Requirements

Summary of Technical Services

A. Automatic Data Processing					
1. Equipment.....	$6	$25	$25	$39	$2
2. Programming and operation.....	95	80	99	106	---
Subtotal.....	$101	$105	$124	$145	$2

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
B. Engineering Services.....	$17	$32	$33	$33	---
C. Scientific and Technical Information and Educational Programs					
1. Operation of NASA technical library..	$72	$82	$83	$88	$13
2. Educational/informational programs..	3	8	8	8	2
Subtotal.....	$75	$90	$91	$96	$15
Total, Technical Services....	$193	$227	$248	$274	$17
A. Automatic Data Processing.....	$101	$105	$124	$145	$2

The current estimate for 1975 is increased from the 1975 budget estimate to provide for wage increases in the support contract for programming and operations services, which were agreed to late in 1974 after formulation of the 1975 budget estimate. The increase in 1976 reflects the lease cost of a remote business terminal acquired in 1975.

B. Engineering Services.....	$17	$32	$33	$33	---

This activity remains at essentially the same level in 1975 and 1976.

C. Scientific and Technical Information and Educational Programs.....	$75	$90	$91	$96	$15
1. Library services.....	$72	$82	$83	$88	$13

The increase in 1976 reflects wage increases in the library services contract and the higher cost of subscriptions.

2. Educational programs.....	$3	$8	$8	$8	$2

This activity reflects the same level in 1975 and 1976.

ADMINISTRATIVE SUPPORT

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
V. ADMINISTRATIVE SUPPORT....	$626	$762	$683	$733	$329

Basis of Fund Requirements

Summary of Administrative Support

A. Communications					
1. Leased lines and long distance.....	$4	$3	$5	$6	$6
2. Local telephone service.....	98	99	118	122	122
3. Other communications..	---	2	---	---	---
Subtotal.....	$102	$104	$123	$128	$128
B. Administrative Printing.....	$51	$50	$57	$62	$62
C. Supplies, Materials and Equipment.....	$384	$520	$402	$458	$98
D. Transportation					
1. Center operations.....	$54	$41	$54	$36	$13
2. Common carrier.....	15	23	23	23	2
Subtotal.....	$69	$64	$77	$59	$15
E. Administrative Support Services					
1. Installation support services.....	$1	---	$1	$1	$1
2. Occupational medicine and environmental health.....	19	24	23	25	25
Subtotal.....	$20	$24	$24	$26	$26
Total, Administrative Support.....	$626	$762	$683	$733	$329

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Communications.....	$102	$104	$123	$128	$128

The current estimate for 1975 is increased from the budget estimate to account for higher wages in the switchboard operations support contract and the higher cost of leased lines. The rise in 1976 reflects the full year cost of these increases.

B. Administrative Printing	$51	$50	$57	$62	$62

The increase in the current estimate for 1975 over the budget estimate provides for the higher renewal cost of the contract for printing and reproduction services. The full year cost of this increase is reflected in 1976.

C. Supplies, Materials and Equipment.....	$384	$520	$402	$458	$98

The lower current estimate for 1975 reflects a reduction in the inventory replacement rates to help offset the increased cost of utilities. The increase in 1976 provides for resumption of normal supply operations.

D. Transportation.....	$69	$64	$77	$59	$15

The current estimate for 1975 is increased from the 1975 budget estimate to provide for updating the avionics equipment on the Wallops administrative aircraft. The estimate for 1976 reflects the return to a normal level of aircraft maintenance.

E. Administrative Support Services.....	$20	$24	$24	$26	$26

The increase in 1976 reflects wage increases for contract medical services.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
ORGANIZATION AND STAFFING CHART
WALLOPS FLIGHT CENTER

STAFFING SUMMARY

	CY 75	BY 76
Excepted	2	2
GS-16	1	1
GS-15	11	11
GS-14	25	25
All Other GS	334	334
Wage Grade	42	42
Total Permanent	415	415

DIRECTOR

	CY	BY
Excepted	2	2
GS-16	-	-
GS-15	2	2
GS-14	-	-
All Other GS	2	2
Wage Grade	-	-
Total Permanent	6	6

OPERATIONS DIRECTORATE

	CY	BY
Excepted	-	-
GS-16	-	-
GS-15	3	3
GS-14	7	7
All Other GS	111	111
Wage Grade	1	1
Total Permanent	122	122

ENGINEERING DIRECTORATE

	CY	BY
Excepted	-	-
GS-16	1	1
GS-15	3	3
GS-14	12	12
All Other GS	73	73
Wage Grade	-	-
Total Permanent	89	89

ADMINISTRATION DIRECTORATE

	CY	BY
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	1	1
All Other GS	68	68
Wage Grade	-	-
Total Permanent	70	70

TECHNICAL SUPPORT DIRECTORATE

	CY	BY
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	-	-
All Other GS	70	70
Wage Grade	41	41
Total Permanent	112	112

APPLIED SCIENCE DIRECTORATE

	CY	BY
Excepted	-	-
GS-16	-	-
GS-15	1	1
GS-14	5	5
All Other GS	10	10
Wage Grade	-	-
Total Permanent	16	16

RPM 6-15

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1976 ESTIMATES

AMES RESEARCH CENTER

DESCRIPTION

The Ames Research Center 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 the Ames Research Center is the U.S. Army Air Mobility Research and Development Laboratory. Personnel from this laboratory work closely with Ames personnel on research of mutual interest. The capital investment at the Ames Research Center, including fixed assets in progress and contractor-held facilities at various locations, as of June 30, 1974, was $325,732,000.

MISSION

The programs at the Ames Research Center are directed toward research and development in the fields of aeronautics, space science, life science, and spacecraft technology, as well as application 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 these areas: Short Haul Aircraft Technology, Simulation Techniques, Theoretical and Experimental Fluid Mechanics, Planetary Atmospheres, Airborne Sciences and Applications, and Aeronautical and Space Life Sciences. In addition to these major program responsibilities, the Center provides support for military programs, the Space Shuttle program, and various civil aviation projects.

The aeronautical research program at Ames is the largest research and development effort at the Center with emphasis placed on theoretical analysis as a basis for the prediction and understanding of fluid flows and on the development of V/STOL aircraft technology. The emphasis in theoretical fluid mechanics will lead to a much stronger role for the computer in the design of future aeronautical vehicles. The Illiac IV computer located at Ames is providing the expanded computational capability needed to support this research. The V/STOL research involves systematic analytical studies and wind tunnel investigations to define and evaluate concepts, simulation studies of the flight characteristics of the concept using flight simulators, and finally, verification with flight vehicles of the technological advances indicated in the research program. These flight vehicles are important to the future of both civil and military aviation, and their success will depend on efficient flight and upon the ability to land and take off quickly and precisely from small areas with safety and regularity under all weather conditions.

Research in Life Sciences is directed toward the search for life elsewhere in the universe, toward understanding the effects of space and aeronautical flight upon humans and other forms of life, and toward providing environments and equipment in spacecraft and aircraft that will permit crews and passengers to exist safely and perform effectively. A major portion of this effort is directed toward understanding the physiological changes that have been observed in manned space flight. The Center's search for extraterrestrial life focuses on such questions as: How did life originate? What chemical events occurred on primitive planets that culminated in organic matter necessary for the appearance of life? Under what extremes of planetary environments can life survive and grow? Answers to all of these questions are relevant to the broader questions of what life forms might be found on other planets and aid in developing spacecraft instrumentation for detecting and characterizing these life forms.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	Functions	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
			(Thousands of Dollars)			
I.	Personnel and Related Costs....	$37,632	$39,497	$39,742	$40,315	$10,363
II.	Travel.....	889	899	815	878	289
III.	Facilities Services	4,625	5,247	5,345	5,618	1,403
IV.	Technical Services.	671	675	626	632	127
V.	Administrative Support.....	2,607	1,638	1,807	1,814	567
	Total, fund requirements.....	$46,424	$47,956	$48,335	$49,257	$12,749

Distribution of Permanent Positions by Program

Over two-thirds of Ames' permanent positions are used in direct support of the various R&D programs. The following table summarizes the actual and planned utilization of positions for direct program activity and for indirect support.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
Direct Positions					
Manned Space Flight					
Space shuttle	2	---	3	3	3
Space flight operations	103	116	112	119	119
Apollo	---	4	---	---	---
Space Sciences					
Physics and astronomy	91	99	81	84	84
Lunar and planetary exploration	164	163	169	159	159
Applications					
Space applications	68	47	51	51	51
Aeronautics and Space Technology					
Aeronautical research and technology	570	637	564	564	564
Space and nuclear research technology	210	218	210	210	210
Technology Utilization	7	7	7	7	7
Subtotal, direct positions	1,215	1,291	1,197	1,197	1,197
Indirect Positions					
Director and staff	34	32	34	34	34
Administrative support	235	260	235	235	235
Research and development support	217	117	210	210	210
Subtotal, indirect positions	486	409	479	479	479
Total, permanent positions	1,701	1,700	1,676	1,676	1,676

PERSONNEL AND RELATED COSTS

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
I. PERSONNEL AND RELATED COSTS.....	$37,632	$39,497	$39,742	$40,315	$10,363
Basis of Fund Requirements					
A. Compensation and Benefits:					
1. Compensation:					
a. Permanent positions	$33,478	$35,189	$35,258	$35,754	$9,040
b. Nonpermanent positions.....	541	605	547	501	220
c. Reimbursable details	115	101	190	225	72
d. Overtime and other compensation.....	352	323	373	376	115
Subtotal, Compensation	$34,486	$36,318	$36,368	$36,856	$9,447
2. Benefits:	$2,912	$3,021	$3,140	$3,225	$810
Subtotal, Compensation and Benefits.....	$37,398	$39,239	$39,508	$40,081	$10,257
B. Supporting Costs:					
1. Transfer of personnel.	$58	$98	$58	$58	$35
2. Personnel training....	176	160	176	176	71
Subtotal, Supporting Costs.....	$234	$258	$234	$234	$106
Total, Personnel and Related Costs.....	$37,632	$39,497	$39,742	$40,315	$10,363
1. Compensation	$34,486	$36,218	$36,368	$36,856	$9,447
a. Permanent positions	$33,478	$35,189	$35,258	$35,754	$9,040

The difference between the 1975 budget estimate and the current estimate for 1975 is the cost of the October 1974 pay raise. This was partially offset by the savings from the reduction in manpower from 1,700 to 1,679.

The increase in 1976 is primarily the full year net cost of these actions.

Basis of Cost for Permanent Positions

In 1976 the cost of permanent positions will be $35,754 an increase of $496 from 1975. This increase results as follows:

Cost of permanent positions in 1975		$35,258
Cost increases:		$+1,375
Within grade advances and career development		
Full year effect of 1975 actions	$+204	
Partial year effect of 1976 actions	+336	
Full year effect of October 1974 pay raise	+560	
Additional extra day	+275	
Cost decreases:		$-879
Full year effect of 1975 manpower reductions	$-354	
Turnover savings		
Full year effect of 1975 actions	-136	
Partial year effect of 1976 actions	-389	
Cost of permanent positions in 1976		$35,754

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Dollars in Thousands)			
b. Nonpermanent positions					
1. Cost	$541	$605	$547	$501	$220
2. Number of manyears	84	91	82	77	34

The 1976 program includes 77 manyears to support the following programs:

Distribution of Nonpermanent Manyears by Program

	Manyears
College cooperative training	18
Summer employment	7
Youth opportunity	31
Other temporary employment	21
Total	77

51-423 O - 75 - 49

The current estimate for 1975 is decreased from the 1975 budget estimate primarily due to a reduction in the level of summer employees from that planned in the 1975 budget. The 1976 estimate reflects the full year effect of reductions made in 1975.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
c. Reimbursable details..	$115	$101	$190	$225	$72

Reimbursable details include 7 military officers and 5 civilians. The current estimate for 1975 shows an increase over the 1975 budget estimate for the addition of five civilian detailees from the General Services Administration who will do computer programming. This increase is offset by a reduction in contracted programming effort in Technical services for Automatic Data Processing.

The 1976 increase reflects the full year cost of reimbursing GSA.

d. Overtime and other compensation.....	$352	$323	$373	$376	$115

Overtime and night differential is used primarily for off-shift operation of major wind tunnel facilities such as the Unitary Plan Wind Tunnel System, the 40 by 80-Foot Wind Tunnel, and the 6 by 6-foot Supersonic Wind Tunnel. The current estimate for 1975 is greater than the 1975 budget estimate to reflect the full year cost of large 1974 Wage Grade pay increases, and the partial year impact of the October 1974 General Schedule pay increase.

The 1976 estimate reflects the full year cost of these pay raises.

2. Benefits	$2,912	$3,021	$3,140	$3,225	$810

The following table indicates the cost of personnel benefits by major categories:

Category of Cost					
Contribution to the Civil Service Retirement Fund....	$2,341	$2,475	$2,475	$2,521	$629
Contribution for employee life insurance.....	119	129	122	123	31
Contribution for employee health insurance.....	407	336	510	553	137
FICA.....	23	64	20	14	8
Incentive awards.....	12	17	13	14	5
Severance pay.....	10	---	---	---	---
Total.....	$2,912	$3,021	$3,140	$3,225	$810

The current estimate for 1975 has increased over the 1975 budget due to the large increase in the cost of health benefits premiums. In addition, the government's contribution to the Federal Health Benefits Program increased from 50% to 60%, effective January 1975.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
B. Supporting Costs	$234	$258	$234	$234	$106
1. Transfer of personnel.....	$58	$98	$58	$58	$35

Based on current turnover estimates, both the current 1975 and the 1976 request provide for 20 moves. The current estimate for 1975 reflects a reduction from the budget estimate.

2. Personnel training...	$176	$160	$176	$176	$71

Personnel training costs provide training with universities and colleges (50%); with technical institutes (30%); with the U. S. Civil Service Commission (5%) and through in-house contracts (15%).

The current estimate for 1975 reflects an increase over the 1975 budget estimate to reflect price increases. 1976 is planned at the 1975 level.

II. TRAVEL.....	$889	$899	$815	$878	$289

Approximately 70% of travel requirements are for program travel involving primary responsibilities in Aeronautics, Life Sciences, Planetary and Earth Science, Astronomy and Applications. Major emphasis is applied on programs such as the Short-Haul Aircraft, Simulation Sciences, Fluid Mechanics, Planetary and Earth Exploration, Airborne Science, and Life Science programs.

The current estimate for 1975 is reduced from the 1975 budget estimate to reflect the recent legislation limiting Federal travel expenses. Travel requirements for 1976 are estimated at the 1975 level and adjusted to take into account increased air fares.

Basis of Fund Requirements

Summary of Travel by Major Category

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Program Travel.....	$573	$630	$585	$629	$207
B. Meetings and Technical Seminars.....	173	125	120	130	45
C. Administrative Travel...	143	144	110	119	37
Total, Travel.....	$889	$899	$815	$878	$289

FACILITIES SERVICES

III. FACILITIES SERVICES..	$4,625	$5,247	$5,345	$5,618	$1,403

Basis of Fund Requirements

Summary of Facilities Services

A. Maintenance and Related Services					
1. Maintenance, repair, and alteration of buildings and grounds.....	$694	$170	$207	$209	$12
2. Custodial services..	921	895	977	1,035	335
3. Maintenance of equipment.....	52	55	60	64	16
Subtotal.....	$1,667	$1,120	$1,244	$1,308	$363
B. Operation of Facilities					
1. Utilities.....	$2,634	$3,935	$3,935	$4,150	$1,000
2. Supplies and equipment.....	324	192	166	160	40
Subtotal.....	$2,958	$4,127	$4,101	$4,310	$1,040
Total, Facilities Services.....	$4,625	$5,247	$5,345	$5,618	$1,403

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Maintenance and Related Services.....	$1,667	$1,120	$1,244	$1,308	$320
1. Maintenance, repair, and alteration of buildings and grounds.....	$694	$170	$207	$209	$12

Building maintenance and repair expenditures cover seven institutional buildings having 251,000 square feet and containing no special purpose equipment other than normal heating and ventilating systems. The year-round requirement for landscaping care requires six manyears of effort for 421.4 acres. The 1974 level reflects one-time repairs for roads, walks, aircraft taxiway, as well as recurring roofing, painting, and electrical repairs.

The current estimate for 1975 reflects an increase over the budget estimate to accommodate wage and price increases. The 1976 program will be maintained at the 1975 level.

2. Custodial services	$921	$895	$977	$1,035	$335

Security, fire protection, janitorial and pest control services encompass 69 buildings, 52 trailers, 13 NASA-owned aircraft, and supply and equipment inventories. Much of the latter is highly sensitive computer and research equipment.

The current estimate for 1975 reflects an increase over the 1975 budget estimate to accommodate wage increases. The further rise in 1976 reflects the full year cost of wage escalation.

3. Maintenance of equipment.....	$52	$55	$60	$64	$16

Maintenance of equipment is provided on an as-needed repair basis. Calls are made generally to local contractors either against Blanket Purchase Agreements or Purchase Orders with fixed labor rates plus current market price for parts. The increase in the current estimates for 1975 from the budget estimate reflects higher labor and material costs.

The 1976 increase reflects the full year cost of the price increases.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
			(Thousands of Dollars)		
B. Operation of Facilities.....	$2,958	$4,127	$4,101	$4,310	$1,040
1. Utilities.....	$2,634	$3,935	$3,935	$4,150	$1,000

Approximately 80% of electric power cost 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.

The 1976 increase results from rate increases based on escalating natural gas and fossil fuel costs by the California Public Utilities Commission, and the Pacific Gas & Electric Company.

2. Supplies and equipment.....	$324	$192	$166	$160	$40

1974 includes $149 for the purchase of automated drafting equipment associated with the Center's safety programs. The current estimates for 1975 and 1976 reflect an overall reduction in the level of supply and equipment purchases.

TECHNICAL SERVICES

IV. TECHNICAL SERVICES.....	$671	$675	$626	$632	$127

Basis of Fund Requirements

Summary of Technical Services

A. Automatic Data Processing					
1. Programming and operations services	$322	$385	$285	$278	$72
B. Engineering Services....	11	---	---	---	---
C. Scientific and Technical Information and Education Programs					
1. Educational/information programs.....	338	290	341	354	55
Total, Technical Services...	$671	$675	$626	$632	$127

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Automatic Data Processing	$322	$385	$285	$278	$72

The current estimate for 1975 decreases from the 1975 budget estimate due to a phase-out of contracted computer programming. This effort is now performed by reimbursable detailees from the General Services Administration. 1976 reflects the full year savings of this realignment.

B. Engineering Services	$11	---	---	---	---
C. Scientific and Technical Information and Educational Programs	$338	$290	$341	$354	$55
1. Education/information programs.....	$338	$290	$341	$354	$55

The 1975 budget estimate assumed a reduction in the level of informational and educational programs. However, with the wide interest in the Pioneer program, these reductions were not realized.

The increased current estimate for 1975 reflects wage and price escalation with no increase to the 1974 level of effort. 1976 reflects the full year cost of these increases.

ADMINISTRATIVE SUPPORT

V. ADMINISTRATIVE SUPPORT...	$2,607	$1,638	$1,807	$1,814	$567

Basis of Fund Requirements

Summary of Administrative Support

A. Communications					
1. Leased lines and long distance tolls.....	$288	$303	$307	$314	$75
2. Local telephone service	362	365	413	419	105
3. Other communications..	---	34	---	---	---
Subtotal.....	$650	$702	$720	$733	$180

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
B. Administrative Printing	$71	$70	$71	$75	$20
C. Supplies, Materials and Equipment.....	$512	$200	$226	$211	$52
D. Transportation					
1. Center operations...	$45	$45	$51	$54	$19
2. Common carrier.....	239	35	37	39	13
Subtotal.....	$284	$80	$88	$93	$32
E. Administrative Support Services					
1. Installation support services.....	$927	$436	$517	$513	$133
2. Environmental health and occupational medicine.....	163	150	185	189	150
Subtotal.....	$1,090	$586	$702	$702	$283
Total, Administrative Support Services.....	$2,607	$1,638	$1,807	$1,814	$567
A. Communications.....	$650	$702	$720	$733	$180

The current estimate for 1975 is greater than shown in the 1975 budget estimate to accommodate rate increases. 1976 reflects the full year cost of these known increases.

B. Administrative Printing	$71	$70	$71	$75	$20

Printing and reproduction requirements during 1975 and 1976 are expected to continue at the 1974 level of effort. 1976 costs have been increased to provide for increased material costs and wage rate increases.

C. Supplies, Materials and Equipment.....	$512	$200	$226	$211	$52

The current estimate for 1975 has increased to reflect the replacement of food preparation equipment which is no longer deemed safe. The 1976 estimate includes a normal level of purchases for supplies, materials and equipment.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
D. Transportation.....	$284	$80	$88	$93	$32

1974 included one-time costs for the transportation of high pressure storage bottles from NASA's Flight Research Center to Ames Research Center. The current estimate for 1975 reflects an increase from the budget estimate for motor pool operations related to labor rate and automotive parts price increases. The increase in 1976 reflects the full cost of these price increases.

E. Administrative Support Services.....	$1,090	$586	$702	$702	$283

The current estimate for 1975 exceeds the 1975 budget estimate due to a large unanticipated wage increase in the support contractor services for supply, warehousing, mail, and delivery services.

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1976 ESTIMATES

FLIGHT RESEARCH CENTER

DESCRIPTION

The Flight Research Center, Edwards, California, is 65 air miles northeast of Los Angeles. The Center is located at the north end of Edwards Air Force Base on 226 acres of land leased from the Air Force. Utilities are provided by the Air Force on a reimbursable basis. The Center is adjacent to Rogers Dry Lake, a 55-square mile area with a complex of runways varying in length from 5 to 11 miles.

The physical plant consists of an office-laboratory building with adjoining shops, a flight maintenance hangar and a calibration hangar, and a high temperature loads calibration facility. Auxiliary buildings include warehouses, and auxiliary power systems building, communications buildings, and an aircraft maintenance dock. The main station of the two station radar range operated by the Center is located on the third floor of the office-laboratory building. The total capital investment of the Flight Research Center, including fixed assets in progress, and contractor-held facilities at various locations, as of June 30, 1974, was $74,199,000.

MISSION

The primary mission of the Flight Research Center, established in 1947, is to maintain a position of preeminence in the conduct of flight research in support of 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 unexpected problems in actual flight.

The current and projected programs at this Center focus on the following types of activities: new design concepts and new flight regimes; flight safety and public acceptance of aircraft operations; applied control technology; improved cost-effective methods of conducting flight research; Space Shuttle development and testing; and energy program efforts.

The various aircraft are the most important of the facilities and special equipment for conducting programs at the Flight Research Center. The aircraft range from low-speed general aviation aircraft for control systems investigations to supersonic aircraft, such as the YF-12, used for various research investigations having application to both civil and military aviation. Special purpose vehicles such as the X-24B, F-8 Digital Fly-By-Wire aircraft,

and unmanned Remotely Piloted Research Vehicles, are contractor procured or developed in-house. Specialized laboratory facilities are available to complement the flight activities with proper preliminary research and testing. Simulation equipment is used to guide and assist in the performance of productive flight activities. A two station test range for radar tracking and data acquisition is operated to support the flight activity.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

Function	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Dollars in Thousands)			
I. Personnel and Related Costs....	$10,061	$10,454	$11,107	$11,346	$3,003
II. Travel.....	246	235	224	242	84
III. Facilities Services.....	1,391	1,364	1,426	1,609	1,500
IV. Technical Services.....	81	91	79	76	52
V. Administrative Support.....	460	348	337	441	268
Total, fund requirements...	$12,239	$12,492	$13,173	$13,714	$4,907

Distribution of Permanent Positions by Program

Over two thirds of Flight's permanent positions are used in direct support of the various R&D programs. The following table summarizes the actual and planned utilization of positions for direct program activity and for indirect support.

Direct Positions

Manned Space Flight

Space flight operations	1	9	1	1	1
Space Shuttle	5	---	40	88	88

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
Aeronautics and Space Technology					
Aeronautical research and technology.....	309	318	281	278	278
Space and nuclear research and technology.....	39	35	40	---	---
Tracking and Data Acquisition	30	27	28	28	28
Energy Program					
Energy technology applications.....	6	---	5	---	---
Technology Utilization	1	1	1	1	1
Subtotal, direct positions.....	391	390	396	396	396
Indirect Positions					
Director and Staff.....	18	18	17	17	17
Administrative support.	75	75	76	76	76
Subtotal, indirect positions.....	93	93	93	93	93
Total, permanent positions.....	484	483	489	489	489

PERSONNEL AND RELATED COSTS

I. PERSONNEL AND RELATED COSTS.....	$10,061	$10,454	$11,107	$11,346	$3,003

Basis of Fund Requirements

A. Compensation and Benefits:

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
1. Compensation:					
a. Permanent positions...	$8,780	$9,109	$9,535	$9,762	$2,541
b. Nonpermanent positions...	237	241	424	415	153
c. Reimbursable detailees..	110	153	128	132	39
d. Overtime and other compensation...	88	94	93	95	24
Subtotal, Compensation...	$9,215	$9,597	$10,180	$10,404	$2,757
2. Benefits.....	796	807	877	892	233
Subtotal, Compensation and Benefits....	$10,011	$10,404	$11,057	$11,296	$2,990
B. Supporting Costs:					
1. Transfer of personnel.....	$12	$10	$10	$10	$3
2. Personnel training.....	38	40	40	40	10
Subtotal, Supporting Costs.....	$50	$50	$50	$50	$13
Total, Personnel and Related Costs.....	$10,061	$10,454	$11,107	$11,346	$3,003
1. Compensation.....	$9,215	$9,597	$10,180	$10,404	$2,757
a. Permanent positions.....	$8,780	$9,109	$9,535	$9,762	$2,541

The current estimate for 1975 is increased from the 1975 budget estimate to reflect the cost of the October 1974 pay raise, plus the cost of the permanent ceiling increases of 6 positions. The increase in ceiling is required to support FRC's role in support of Shuttle Flight Tests.

The increase in 1976 is primarily the full year net cost of these actions.

Basis of Cost of Permanent Positions
(Thousands of Dollars)

In 1976 the cost of permanent positions will be $9,762, an increase of $227 from 1975. The increase results as follows:

Cost of permanent positions in 1975		$9,535
Cost increases:		+395
Within grade advances and career development		
Full year effect of 1975 actions	+$ 93	
Partial year effect of 1976 actions	+ 92	
Full year effect of October 1974 pay raise	+ 125	
Additional extra day	+ 32	
Full year effect of 1975 new positions	+ 53	
Cost decreases:		-168
Turnover savings		
Full year effect of 1975 actions	-$ 91	
Partial year effect of 1976 actions	- 77	
Cost of permanent positions in 1976		$9,762

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Dollars in Thousands)			
b. Nonpermanent positions:					
1. Cost	$237	$241	$424	$415	$153
2. Number of manyears	35	38	64	64	24

The 1976 program includes 64 manyears to support the following programs:

Distribution of Nonpermanent Manyears by Program

	Positions
College cooperative training	40
Opportunity programs	14
Summer employment	7
Other temporary employment	3
Total	64

The current estimate for 1975 increases from the 1975 budget estimate due to the October 1974 pay raise and an earlier than planned implementation of the college cooperative training program based on an increased availability of students in the job market. The program for 1976 is planned at essentially the same level as 1975.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
c. Reimbursable detailees..	$110	$153	$128	$132	$39

The services of military officers are utilized in FRC's programs where such assignments are of mutual benefit.

The current estimate for 1975 is decreased from the 1975 budget estimate as a result of the availability of only 9 military personnel with the skills required, rather than the 11 originally planned. The 1976 estimate reflects the full year cost of the 9 detailees.

d. Overtime and other compensation....	$88	$94	$93	$95	$24

Overtime is restricted to emergency repairs and work required beyond normal duty time. Requirements include overtime pay for personnel involved with flight launches, emergency repairs of equipment and facilities which occur outside normal working hours and completion of special projects and programs to meet specific deadlines.

The current estimate for 1975 was slightly reduced from the 1975 budget estimate as a result of the effort to reduce requirements and is offset by an increase for the October 1974 pay raise. The 1976 estimate continues overtime at approximately the same level, but the estimate increases slightly due to the full year effect of the October 1974 pay raise.

2. Benefits.....	$796	$807	$877	$892	$233

The following table indicates the cost of personnel benefits by major categories:

Category of Cost					
Contribution to the Service Retirement Fund.....	$624	$649	$694	$700	$182

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Category of Cost (Cont'd)					
Contribution for employee life insurance.....	31	33	33	34	9
Contribution for employee health insurance.....	120	101	130	138	35
Contribution to FICA.....	5	9	8	8	4
Incentive awards...	5	10	7	7	2
Other personnel benefits.....	---	5	5	5	1
Severance pay.....	11	---	---	---	---
Total.....	$796	$807	$877	$892	$233

The current estimate for 1975 is increased over the 1975 budget estimate due to the increase of six permanent positions, the October 1974 pay raise and the higher Government contribution for health insurance. The 1976 increase provides for the full year cost of these actions.

B. Supporting Costs					
1. Transfer of personnel.....	$12	$10	$10	$10	$3
2. Personnel training.....	38	40	40	40	10
Total.....	$50	$50	$50	$50	$13

Supporting costs include those expenses associated with movement of employees to new duty stations. This estimate provides for the movement of approximately 9 personnel, which is the average for prior years.

It also includes the cost for tuition, fees and related costs for training at colleges, universities, technical institutes and other institutions. It is estimated that this activity in 1976 will continue at the current level.

II. TRAVEL.....	$246	$235	$224	$242	$84

The major portion of the travel will be support of the Aeronautics program, with the Space Shuttle requiring a larger share in 1975 and 1976.

The 1975 current estimate has been realigned by subfunction to reflect 1974 experience and the total has been reduced consistent with the recent legislation curtailing federal travel expenses.

The 1976 travel is continued at the 1975 level and takes into account increased air fares.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)				
A. Program Related Travel.....	$121	$103	$121	$132	$45
B. Meetings and Technical Seminars.....	99	106	79	84	27
C. Administrative Travel.....	26	26	24	26	12
Total, Travel.....	$246	$235	$224	$242	$84
III. FACILITIES SERVICES..	$1,391	$1,364	$1,426	$1,609	$1,500
A. Maintenance and Related Services					
1. Maintenance of buildings and grounds.....	$824	$681	$769	$904	$896
2. Maintenance of equipment.....	91	90	90	90	22
3. Custodial services.....	307	320	387	413	400
Subtotal.....	$1,222	$1,091	$1,246	$1,407	$1,318
B. Operation of Facilities					
1. Utilities.....	$120	$228	$152	$164	$164
2. Supplies and equipment.....	49	45	28	38	18
Subtotal.....	$169	$273	$180	$202	$182
Total, Facilities Services	$1,391	$1,364	$1,426	$1,609	$1,500

51-423 O - 75 - 50

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Maintenance and Related Services...	$1,222	$1,091	$1,246	$1,407	$1,318
1. Maintenance of buildings and grounds.....	$824	$681	$769	$904	$896

The funding for maintenance of buildings and grounds is used to repair and maintain 374,000 square feet of building space, 21 permanent structures, utility plants and systems, 219 acres of improved and unimproved grounds, and other real property items.

The current estimate for 1975 increased from the 1975 budget estimate as a result of support service contractor wage and material cost escalation. The 1976 increase is attributable to the full year effect of these increased costs. The transition period reflects twelve months funding consistent with the Center's normal obligation practice.

2. Maintenance of equipment.....	$91	$90	$90	$90	$22

This estimate is based on maintaining approximately 300 pieces of office, shop and laboratory equipment through on call service maintenance contracts. The 1976 estimate reflects the continuation of this activity at current levels.

3. Custodial services	$307	$320	$387	$413	$400

The estimate for janitorial services will provide funds to clean 207,000 square feet of floor space and adequate security protection services of buildings and grounds.

The current estimate for 1975 increased from the 1975 Budget Estimate as a result of support service contractor wage and material cost escalation. The 1976 increase is attributable to the full year cost of this escalation. The transition period reflects the Center's normal obligation practice.

B. Operation of Facilities.....	$169	$273	$180	$202	$182
1. Utilities.....	$120	$228	$152	$164	$164

Electricity and water are obtained from the Air Force and natural gas is obtained from a commerical source.

The current estimate for 1975 decreased from the 1975 budget estimate to reflect a reduction in estimated utility usage consistent with continuing measures to conserve energy. The 1975 current estimate is reflective of current utility rates. In 1976 utility consumption is planned at the same level as 1975. A full twelve month funding is reflected in the transition period.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
2. Supplies and equipment.....	$49	$45	$28	$38	$18

The current estimate for 1975 decreased from the 1975 budget estimate due to a deferral of equipment purchases. The increase in 1976 reflects the purchase of the deferred procurement and the higher cost of fuel and lubricants, electronic and general service materials.

IV. TECHNICAL SERVICES...	$81	$91	$79	$76	$52

Basis of Fund Requirements

Summary of Technical Services

A. Automatic Data Processing					
1. Programming and operations services.....	$16	$16	$16	$16	$16
2 Equipment.....	2	3	---	---	---
Subtotal.....	$18	$19	$16	$16	$16
B. Engineering Services	$6	$10	$6	$6	$2
C. Scientific and Technical Information and Educational Programs					
1. Operation of NASA technical libraries.....	$12	$12	$12	$12	$3
2. Educational/Information programs	28	33	28	28	22

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
C. Scientific and Technical Information and Educational Programs (Cont'd)					
3. Scientific and technical information....	$17	$17	$17	$14	$9
Subtotal.....	$57	$62	$57	$54	$34
Total, Technical Services	$81	$91	$79	$76	$52
A. Automatic Data Processing.....	$18	$19	$16	$16	$16

The current estimate for 1975 decreased from the 1975 budget estimate to reflect the cancellation of the lease of programmable typewriters subsequent to the submission of the 1975 budget. The transition period reflects a twelve month funding plan.

B. Engineering Services..	$6	$10	$6	$6	$2

Funding in this area is in support of the Center facilities management function. Engineering services are required primarily for drafting and design work which exceed in-house capability, engineering consulting services, and civil engineering facility design approvals.

The current estimate for 1975 decreases from the budget estimate to reflect current estimated needs.

C. Scientific and Technical Information and Educational Programs	$57	$62	$57	$54	$34
1. Operation of NASA technical libraries.....	$12	$12	$12	$12	$3

Funding in this area is required to procure scientific and technical books and periodicals in support of research programs; technical and administrative publications; various other publications of scientific value and approximately 300 subscriptions for periodicals. The 1976 budget reflects the continuance of this activity at the current level.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
2. Educational/ information programs.....	$28	$33	$28	$28	$22

The educational/information programs provide 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 elementry and secondary levels.

The current estimate for 1975 decreased from the 1975 budget estimate and reflects the decision to cancel the publication of certain brochures.

The 1976 budget reflects the continuance of this activity at the current level. The transition period reflects the centers normal obligation pattern.

3. Scientific and technical information....	$17	$17	$17	$14	$9

Funding in this area will allow the procurement of documentation, publication services and photographic services.

The reduction in 1976 is the result of reduced contracted effort.

V. ADMINISTRATIVE SUPPORT.....	$460	$348	$337	$441	$268

Basis of Fund Requirements

Summary of Administrative Support

A. Communications					
1. Leased lines and long distance tolls.....	$48	$58	$45	$52	$52
2. Local telephone service.....	61	62	62	62	62
3. Other communications.....	3	3	3	3	3
Subtotal.....	$112	$123	$110	$117	$117

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
B. Administrative Printing.....	$16	$20	$16	$20	$5
C. Supplies, Materials and Equipment.....	$217	$96	$106	$186	$63
D. Transportation					
1. Center operations	$89	$79	$79	$88	$68
2. Common carrier...	16	20	16	20	5
Subtotal.....	$105	$99	$95	$108	$73
E. Administrative Support Services...	$10	$10	$10	$10	$10
Total, Administrative Support.....	$460	$348	$337	$441	$268
A. Communications.....	$112	$123	$110	$117	$117

This category provides funding to support three Federal Telephone System circuits, local telephone service, and the rental of equipment for the teletype/crypto system.

The current estimate for 1975 decreased from the 1975 budget estimate to reflect actual rates experienced during the prior fiscal year. The increase in the 1976 estimate is due to additional support required for the Shuttle Program activity. The transition period represents twelve months funding.

B. Administrative Printing.....	$16	$20	$16	$20	$5

Administrative printing includes the contractual publication of information and materials such as in-house organ weekly and the related composition and binding operations.

The current estimate for 1975 decreased from the 1975 budget estimate due to the determination to defer printing of certain publications for an additional year. The increase in 1976 provides for the printing of those publications.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
C. Supplies, Materials and Equipment.....	$217	$96	$106	$186	$63

Administrative supplies, materials and equipment include those items of a general nature which service the entire installation. The majority of the funds are budgeted for office supplies and equipment to support administration. The 1974 amount includes a significant replacement of office furniture which is not required annually.

The current estimate for 1975 increased from the 1975 budget estimate to reflect current pricing levels. The 1976 budget increase is primarily due to the replacement of outmoded reproduction equipment and higher cost of supplies, materials, and equipment.

D. Transportation.....	$105	$99	$95	$108	$73

Estimates in this area are to fund the costs of government bills of lading issued to common carriers to move freight by rail, truck, water, air and to fund shipments provided by United Parcel Service. Contractor maintenance of the Center's general purpose vehicles is included herein.

The current estimate for 1975 decreased from the budget estimate to reflect lower cost of transporting trailers from the closed AEC facility at Jackass Flats, NV to FRC. The 1976 increase is the result of support service contractor wage and price escalation.

E. Administrative Support Services...	$10	$10	$10	$10	$10

Administrative support services provides for the Center's pilots' physical examiniations. The transition period reflects a full twelve months funding.

FY 1976 BUDGET ESTIMATES

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORGANIZATION AND STAFFING CHART

FLIGHT RESEARCH CENTER

STAFFING SUMMARY	CY	BY
Excepted	8	8
GS-16	3	3
GS-15	20	20
GS-14	35	35
All Other GS	421	421
Wage Board	2	2
Total Permanent	489	489

OFFICE OF THE DIRECTOR	CY	BY
Excepted	3	3
GS-16	-	-
GS-15	5	5
GS-14	1	1
All Other GS	30	30
Wage Board	-	-
Total Permanent	39	39

RESEARCH DIVISION	CY	BY
Excepted	2	2
GS-16	2	2
GS-15	5	5
GS-14	18	18
All Other GS	71	71
Wage Board	-	-
Total Permanent	98	98

OPERATIONS DIRECTORATE	CY	BY
Excepted	2	2
GS-16	1	1
GS-15	6	6
GS-14	5	5
All Other GS	140	140
Wage Board	-	-
Total Permanent	154	154

DATA SYSTEMS DIVISION	CY	BY
Excepted	1	1
GS-16	-	-
GS-15	2	2
GS-14	7	7
All Other GS	123	123
Wage Board	-	-
Total Permanent	133	133

ADMINISTRATIVE DIRECTORATE	CY	BY
Excepted	-	-
GS-16	-	-
GS-15	2	2
GS-14	4	4
All Other GS	57	57
Wage Board	2	2
Total Permanent	65	65

RPM 8-15

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1976 ESTIMATES

LANGLEY RESEARCH CENTER

DESCRIPTION

The Langley Research Center, Hampton, Virginia, is located approximately 100 air miles south of Washington, D.C. The Center occupies 772 acres of Government-owned land, divided into two areas by the runway facilities of Langley Air Force Base. The West Area consists of 749 acres, 430 owned by NASA and 319 under permit from the Air Force. The East Area comprises 23 acres under Air Force permit. 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 Air Force. The total acreage presently owned, under permit, or leased, is 4,158. The total capital investment at the Langley Research Center, including fixed assets in progress, and contractor-held facilities at various locations as of June 30, 1974, was $488,129,000.

MISSION

The Langley Research Center is responsible for complex research programs in aeronautics, space science, electronics, and structures. Major activities at Langley include management of the Viking project; development of aeronautical and space vehicles concepts; consultation and research aid to many Governmental agencies, industry, and universities; and release of research results to scientific and technical communities.

A substantial percentage of Langley's research work is in the development of advanced concepts and technology for future aircraft, with particular emphasis on environmental effects, performance, range, safety, and economy. Examples of this research are projects involving a supercritical wing, composite structural materials, and automatic flight control systems. Work continues in the development of technology for helicopters and avionic systems for reliable operations in terminal areas of the future.

Vigorous efforts continue to improve supersonic flight capabilities for both transport and military aircraft. Configurations under study attempt to maximize the favorable interference effects of aerodynamics and propulsion. The advanced research program is also aimed at the technology required for aircraft performance in the hypersonic speed range.

Langley works with the general aviation industry to help solve problems concerning aircraft design, to generate and consolidate data and techniques for new designs and load requirements, and to develop new devices to improve flight operations. Simplified, low cost electronic systems that will aid stability, navigation, and collision warning are also being developed.

Materials and structural systems are being evolved to work effeciently in critical environments, practical methods of cooling high-heat areas of aircraft surfaces are being studied, and the technology of hypersonic ramjet engines is being developed.

Other aeronautical research at Langley focuses on critical problems of aircraft engine noise, alleviation of trailing vortices, increased traction and control of landing gear, and improved physical comfort in aircraft.

Langley has complete responsibility for Viking, a spacecraft that will orbit and land on Mars in 1976. Viking will permit a detailed study of geophysics, atmospheric characteristics and surface properties of Mars and obtain data relevant to the evidence of life forms on the planet. Langley was selected to manage the Viking project because of the Center's experience and contributions to advanced technology in the fields of atmospheric entry heat shielding, space vehicle recovery systems, rocket propulsion, instrumentation, and electronics.

Langley supports unmanned spacecraft programs by the development of experiments and sensors, communications, and data handling systems. These programs include the remote sensing of water and air pollution, survey of earth resources, and the application of space technology to measure various physical phenomena ranging from ocean wave heights to upper atmospheric composition.

Scout launch vehicle operations and improvements in national and international satellite experiments are long-time Langley responsibilities.

Ground-based research programs at Langley include the investigation of effects on space vehicles such as heat, vacuum, noise, and meteoroids; the development and use of advanced composite and polymeric materials for structures and thermal control systems; and improved technology for antenna and power amplifiers, batteries, high-capacity computer memories, logic circuits, and other advanced microelectronic devices.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	Functions	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
			(Dollars in Thousands)			
I.	Personnel and Related Costs.....	$69,967	$72,601	$74,698	$76,036	$19,494
II.	Travel.....	1,903	1,910	1,980	2,267	681
III.	Facilities Services.	6,345	5,895	6,421	7,172	1,890
IV.	Technical Services..	1,549	1,208	1,171	1,202	380
V.	Administrative Support.....	3,995	3,375	3,834	4,033	942
	Total, fund requirements.....	$83,759	$84,989	$88,104	$90,710	$23,387

Distribution of Permanent Positions by Program

Over two-thirds of Langley's permanent positions are used in direct support of the various R&D programs. The following table summarizes the actual and planned utilization of positions for direct program activity and for indirect support.

Direct Positions					
Manned Space Flight					
Space flight operations	5	62	12	6	8
Apollo.....	2	---	---	---	---
Space Science					
Physics and astronomy..	125	55	90	26	26
Lunar and planetary exploration.....	264	277	222	167	167
Launch vehicle procurement.....	50	54	62	62	62
Applications					
Space applications.....	195	227	217	253	253

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
Aeronautics and Space Technology					
Aeronautical research and technology.....	1,450	1,439	1,459	1,499	1,499
Space and nuclear research and technology.....	511	489	536	585	585
Tracking and Data Acquisition.....	9	13	---	---	---
Technology Utilization...	8	14	17	15	15
Subtotal, direct positions.....	2,619	2,630	2,615	2,615	2,615
Indirect Positions					
Director and staff.....	10	10	16	16	16
Administrative support.	420	418	388	388	388
Research and development support..	326	313	313	313	313
Subtotal, indirect positions.....	756	741	717	717	717
Total, permanent positions.....	3,375	3,371	3,332	3,332	3,332

PERSONNEL

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
I. PERSONNEL.....	$69,967	$72,601	$74,698	$76,036	$19,494

Basis of Fund Requirements

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Compensation and Benefits:					
1. Compensation:					
a. Permanent positions..	$62,528	$64,770	$66,336	$67,395	$17,169
b. Nonpermanent positions..	801	976	1,184	1,180	413
c. Reimbursable details....	---	---	47	53	13
d. Overtime and other compensation..	566	546	602	618	155
Subtotal, Compensation..	$63,895	$66,292	$68,169	$69,246	$17,750
2. Benefits.....	$5,557	$5,794	$6,014	$6,275	$1,615
Subtotal, Compensation and Benefits	$69,452	$72,086	$74,183	$75,521	$19,365
B. Supporting Costs:					
1. Transfer of personnel.....	$96	$40	$96	$96	$23
2. Personnel training.....	419	475	419	419	106
Subtotal, Supporting Costs..	$515	$515	$515	$515	$129
Total, Personnel and Related Costs.....	$69,967	$72,601	$74,698	$76,036	$19,494
1. Compensation.....	$63,895	$66,292	$68,169	$69,246	$17,750
a. Permanent positions.....	62,528	64,770	66,336	67,395	17,169

The difference between the 1975 budget estimate and the current estimate for 1975 is the cost of the October 1974 pay raise. This is partially offset by the savings resulting from the reduction in manpower from 3,371 to 3,332. The increase in 1976 is primarily the full year net cost of these actions.

Basis of Cost for Permanent Positions
(Thousands of Dollars)

In 1976 the cost of permanent positions will be $67,395 an increase of $1,059 from 1975. This increase results as follows:

Cost of permanent positions in 1975		$66,336
Cost increases:		+2,626
Within grade advances and career development		
Full year effect of 1975 actions	+$565	
Partial year effect of 1976 actions	+793	
Full year effect of October 1974 pay raise	+1,008	
Additional extra day	+260	
Cost decreases:		-$1,567
Full year effect of 1975 manpower reductions	-$286	
Turnover savings		
Full year effect of 1975 actions	-668	
Partial year effect of 1976 actions	-613	
Cost of permanent positions in 1976		$67,395

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Dollars in Thousands)			
b. Nonpermanent positions:					
1. Cost	$801	$976	$1,184	$1,180	$413
2. Number of manyears	123	162	168	170	60

The 1976 program includes 170 manyears to support the following programs:

Distribution of Nonpermanent Manyears by Program

Program	Manyears
College cooperative training	84
Summer employment	24
Opportunity programs	47
Other temporary employment	15
Total	170

The current estimate for 1975 has increased from the 1975 budget estimates due to the October 1974 pay raise and increased minority and female participation in the college cooperative training program. The program for 1976 is planned at essentially the 1975 level.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
c. Reimbursable details.....	---	---	$47	$53	$13

The current estimate for 1975 includes funding for the services of two experienced Army test pilots who will participate in experimental flight programs including spin tests on military aircraft and flights of terminal configured vehicles. This requirement was not included in the 1975 budget. 1976 reflects the full year cost of these pilots.

d. Overtime and other compensation.....	$566	$546	$602	$618	$155

The current estimate for 1975 allows for general schedule and wage grade increases which were not included in the 1975 budget estimate. The 1976 estimate reflects the full year cost of these pay raises.

2. Benefits.....	$5,557	$5,794	$6,014	$6,275	$1,615

The distribution of these costs by major categories is as follows:

Category of Cost					
Contribution to the Civil Service Retirement Fund..	$4,394	$4,664	$4,691	$4,765	$1,214
Contribution for employee life insurance.....	237	273	240	274	79
Contribution for employee health insurance.....	816	714	1,014	1,176	307
Contribution to FICA.....	17	13	28	28	7
Incentive awards...	30	35	30	30	8
Other personnel benefits.....	1	95	2	2	---
Severance pay.....	62	---	9	---	---
Total.....	$5,557	$5,794	$6,014	$6,275	$1,615

The current estimate for 1975 has increased over the 1975 budget due to the large increase in the cost of health benefits services. In addition, there was a 20% increase in the government's contribution to the Federal Health Benefits Program effective January 1975.

The increase in 1976 reflects the full year cost of the increased government contribution.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
B. Supporting Costs	$515	$515	$515	$515	$129
1. Transfer of personnel.....	$96	$40	$96	$96	$23

The 1975 budget estimate categorized subsistence, miscellaneous moving expenses, and real estate costs under "other personnel benefits". These costs are now shown here. Both 1976 and 1976 are based on the 1974 experience of 38 moves.

2. Personnel training.....	$419	$475	$419	$419	$106

The current estimates for 1975 and 1976 are held to the same level of costs as experienced in 1974. Higher tuition costs have been offset by reducing the number of participants in professional and administrative short courses and seminars.

TRAVEL

II. TRAVEL.....	$1,903	$1,910	$1,980	$2,267	$681

Over one-half of Langley travel is associated with the Viking Project. This is required to ensure the maintenance of a critical launch schedule and to provide timely program direction in order to minimize development costs. Other areas in aeronautics and space requiring focused effort include the Advanced Supersonic Technology program, Rotor Systems Research aircraft, Hypersonic Research Aircraft technology, General Aviation, and Terminal Configured Vehicles as well as the Scout project and Nimbus G.

The current estimate for 1975 is increased over the 1975 budget estimate to satisfy requirements for Program Related Travel. Reductions reflecting the recent legislation limiting Federal travel expenses have been made, but are offset by additions for Viking Program travel.

The increase in 1976 reflects a small increment for Program Related Travel, and an adjustment of the 1975 level to take into account increased air fare tariffs.

Basis of Fund Requirements

Summary of Travel by Major Category

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
	(Thousands of Dollars)				
A. Program related travel.....	$1,436	$1,389	$1,616	$1,874	$587
B. Meetings and technical seminars.....	118	171	95	102	25
C. Administrative travel	349	350	269	291	69
Total.....	$1,903	$1,910	$1,980	$2,267	$681
A. Program related travel.....	$1,436	$1,389	$1,616	$1,874	$587

The current estimate for 1975 is increased over the 1975 budget estimate to assure close program direction and coordination of the Viking program. Timely reviews are essential to minimize engineering costs, and to ensure maintenance of critical schedules preparatory to vehicle launch. The increase in 1976 includes an increment for travel associated with post-launch, flight and mission operations of the Viking and Nimbus G projects.

B. Meetings and technical seminars.....	$118	$171	$95	$102	$25
C. Administrative travel.....	$349	$350	$269	$291	$69

For Meetings and Technical Seminars and Administrative Travel the current estimate for 1975 is reduced from the 1975 budget estimate to reflect the recent legislation curtailing Federal travel expenses. Travel requirements for 1976 are estimated at the 1975 level, and adjusted to take into account increased air fares.

FACILITIES SERVICES

III. FACILITIES SERVICES..	$6,345	$5,895	$6,421	$7,172	$1,890

51-423 O - 75 - 51

Basis of Fund Requirements

Summary of Facilities Services

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Maintenance and Related Services					
1. Maintenance of buildings and grounds.....	$1,081	$994	$342	$795	$235
2. Custodial services.....	1,233	1,242	1,377	1,441	375
3. Maintenance of equipment.....	70	80	70	74	20
Subtotal.....	$2,384	$2,316	$1,789	$2,310	$630
B. Operation of Facilities					
1. Utilities.....	$2,407	$2,326	$3,420	$3,625	$940
2. Supplies and equipment.....	1,554	1,253	1,212	1,237	320
Subtotal.....	$3,961	$3,579	$4,632	$4,862	$1,260
Total, Facilities Services	$6,345	$5,895	$6,421	$7,172	$1,890
A. Maintenance and Related Services...	$2,384	$2,316	$1,789	$2,310	$630
1. Maintenance, repair and alterations of buildings and grounds.....	$1,081	$994	$342	$795	$235

The current estimate for 1975 is decreased from the 1975 budget estimate by deferring maintenance. This action, although undesirable, was necessary to allow the use of these funds to cover the rising cost of utilities.

The increase in 1976 provides for partial resumption of the deferred mainteneance.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
2. Custodial services.....	$1,233	$1,242	$1,377	$1,441	$375

The current estimate for 1975 is increased over the 1975 budget estimate to account for wage escalation. The increase in 1976 reflects the full year cost of the 1975 labor agreements.

3. Maintenance of equipment.....	$70	$80	$70	$74	$20

The 1975 current estimate is decreased from the budget estimate to reflect a lower level of equipment maintenance. The equipment inventory was reduced to offset the escalated cost of services. The increase in 1976 reflects the full year cost of wage escalation.

B. Operation of Facilities.....	$3,961	$3,579	$4,632	$4,862	$1,260
1. Utilities.....	$2,407	$2,326	$3,420	$3,625	$940

The estimates for 1975 and 1976 reflect the same level of usage as in 1974. The increase in the current estimate for 1975 from the 1975 budget estimate covers a further rise in utility rates of approximately 42%. The increase in 1976 reflects the full year cost of this higher rate.

2. Supplies and equipment.....	$1,554	$1,253	$1,212	$1,237	$320

The current estimate for 1975 is decreased from the 1975 budget estimate due to a reduction in the amount of supplies and materials purchased. This decrease was partially offset by increased prices for electronic materials, fuels and lubricants. The increase in 1976 provides for the full year cost of these price increases.

TECHNICAL SERVICES

IV. TECHNICAL SERVICES...	$1,549	$1,208	$1,171	$1,202	$380

Basis of Fund Requirements

Summary of Technical Services

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
A. Automatic Data Processing					
1. Equipment.....	$108	$74	$119	$119	$40
2. Programming and operation services.....	1,036	978	707	758	260
Subtotal.....	$1,144	$1,052	$826	$877	$300
B. Engineering Services.	$84	---	$40	---	---
C. Scientific and Technical Information and Educational Programs					
1. Library services.	$26	---	$26	$28	$5
2. Educational.....	295	156	279	297	75
Subtotal.....	$321	$156	$305	$325	$80
Total, Technical Services	$1,549	$1,208	$1,171	$1,202	$380
A. Automatic Data Processing	$1,144	$1,052	$826	$877	$300

The current estimate for 1975 was decreased from the 1975 budget estimate to reflect a reduction in programming and operation services. Curtailment of these services was necessary to free up funds to cover the increasing cost of utilities. The increase in the 1976 estimate is for higher wage rates on existing contracts; the level of about 37 manyears of effort is the same as in 1975.

B. Engineering Services.	$84	---	$40	---	---

The increase in the current estimate for 1975 over the budget estimate reflects the cost of a systems study on warehouse operations. This study is intended to effect operating economies by automating the requisitioning and control functions. We do not anticipate similar services to be required in 1976.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
C. Scientific and Technical Information and Educational Programs	$321	$156	$305	$325	$80
1. Library services..	$26	---	$26	$28	$5

The current estimate for 1975 is for library services which were included under Administrative support services in the 1975 budget estimate. They are shown here to better characterize the support provided. The increase in 1976 reflects wage rate escalation.

2. Educational programs.....	$295	$156	$279	$297	$75

The current estimate for 1975 is an increase over the 1975 budget estimate for new opportunity programs for the disadvantaged, and for the increased cost of operating the Visitor Center. The increase in 1976 reflects the full year cost of the expanded opportunity programs started in 1975.

ADMINISTRATIVE SUPPORT

V. ADMINISTRATIVE SUPPORT.....	$3,995	$3,375	$3,834	$4,033	$942

Basis of Fund Requirements

Summary of Administrative Support

A. Communications					
1. Leased lines and long distance tolls.....	$350	$400	$432	$452	$113
2. Local service....	700	760	819	853	212
3. Other communications.....	4	8	4	4	1
Subtotal.....	$1,054	$1,168	$1,255	$1,309	$326
B. Administrative Printing.....	$20	$41	$20	$20	$5
C. Supplies, Materials and Equipment.....	$704	$555	$654	$689	$147

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
D. Transportation					
1. Center operations	$536	$270	$573	$629	$155
2. Common carrier...	79	254	85	90	20
Subtotal.....	$615	$524	$658	$719	$175
E. Administrative Support Services					
1. Installation support services	$1,398	$887	$1,021	$1,060	$227
2. Medical services.	204	200	226	236	62
Subtotal.....	$1,602	$1,087	$1,247	$1,296	$289
Total, Administrative Support.....	$3,995	$3,375	$3,834	$4,033	$942
A. Communications.....	$1,054	$1,168	$1,255	$1,309	$326

The current estimate for 1975 is increased over the 1975 budget estimate to account for rate increases in maintenance, repair, installation, and relocation of telephone instruments. The increase in 1976 reflects the full year costs of the 1975 service rate increase.

B. Administrative Printing.....	$20	$41	$20	$20	$5

The current estimate for 1975 is reduced from the 1975 budget estimate because of a change to in-house printing and binding operations rather than commerical contracts as previously planned. The 1976 program is maintained at the 1975 level.

C. Supplies, Materials and Equipment	$704	$555	$654	$689	$147

The current estimate for 1975 increased from the 1975 budget due to the increased cost of aviation fuel required in the operation of NASA aircraft. The increase in 1976 reflects the full year cost of the higher fuel prices.

D. Transportation.....	$615	$524	$658	$719	$175

The current estimate for 1975 is increased over the 1975 budget estimate to account for higher wage rates and material prices for maintenance and operations of NASA aircraft. The increase in 1976 is for engine overhaul of NASA aircraft.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
E. Administrative Support Services...	$1,602	$1,087	$1,247	$1,296	$289

This function includes support for mail, warehousing, and medical services. The current estimate for 1975 is increased from the 1975 budget estimate because of wage increases for contracted services. The 1976 program is planned at the 1975 level; however, the increase reflects the full year cost of 1975 wage increases.

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1976 ESTIMATES

LEWIS RESEARCH CENTER

DESCRIPTION

The Lewis Research Center occupies two sites in north central Ohio. The older one, established in 1941 adjacent to the Cleveland-Hopkins International Airport, occupies 366 acres including 14 acres leased from the City of Cleveland. Here there are over 100 buildings, including two large supersonic wind tunnels, a V/STOL subsonic tunnel, large Propulsion Systems Laboratories with four large altitude test chambers suitable for testing full scale aircraft engines and other airbreathing power conversion systems requiring altitude conditions, a High Pressure Turbine and Combustor Facility, an Engine Fan and Jet Noise Facility, Engine Components Research Laboratories, a Zero Gravity Research Facility, Space Power Chambers, Electric Propulsion Research Laboratory, Energy Conversion Laboratories, five materials research buildings, a High Energy Fuels Laboratory, an Instrument Research Laboratory, a Chemistry Laboratory and an Engine Research Building.

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. It occupies 8,045 acres of which 7,989 are owned by the Government and 56 are in easements. There are 122 buildings and 99 concrete storage bunkers. The major facilities include the Space Power Facility, Spacecraft Propulsion Research Facility, Hypersonic Tunnel Facility, Cryogenic Propellant Tank Facility, Altitude Rocket Test Facility, and Reactor Facility. A new 100 KW Electric Wind Turbine Generator Facility is being constructed for a program jointly sponsored by the National Science Foundation and NASA. During the second half of FY 1975, consistent with our future research and technology needs, the Plum Brook Station will be placed in a standby mode.

The total capital investment of the Lewis Research Center as of June 30, 1974 was $443,649,000 of which $51,496,000 represents facilities held by contractors at various locations.

MISSION

The Lewis Research Center's major areas of emphasis are research and technology programs on aircraft propulsion, space power, space propulsion, and communications systems and procurement and launch services for missions using Centaur.

Lewis is responsible for the management of the Atlas/Centaur and Titan/Centaur launch vehicles. This includes the procurement of these vehicles and

provision of launch services for missions utilizing them. In aeronautical propulsion, Lewis research supports the determination of the capabilities and limitations of full-scale engines over their complete range of operation and the reduction of aircraft noise. Aircraft engines for future subsonic and supersonic aircraft with high compressor pressure ratios and high turbine inlet temperatures are being investigated. High flight Mach number aircraft engine inlets, combustion nozzles, and systems are being investigated.

A flight test program is being conducted with an F-106 airplane to determine the interactions of engine inlets and exhaust nozzles with wings and fuselage at transonic speeds. An experimental flight program is being implemented utilizing the YF-12 aircraft in cooperation with the Flight Research Center. Propulsion control techniques are being developed to increase compatibility of engine/inlet propulsion interactions with airframe and aircraft end-use requirements.

The electric power generation technology effort encompasses photovoltaic, electrochemical, static, and dynamic systems.

The space propulsion programs include chemical and electric propulsion technology and component and systems development. Chemical propulsion programs are providing the technology for an advanced high-performance reusable Hydrogen-Oxygen Upper Stage Space Propulsion System for near-earth space missions. Both primary and auxiliary electric thrusters of the electron bombardment type are being developed for foreseeable applications.

The Center has maintained a substantial materials research effort aimed at raising the physical limitations of materials to allow the improvement of component and system performance of propulsion and power generation systems, launch vehicles, and spacecraft. Materials being investigated include composites, titanium alloys, superalloys of nickel and cobalt base, refractory metals, dispersion strengthened metals, and ceramics.

Lewis is responsible for the development of the transmitter and power tube for the Cooperative Applications Satellite (CAS), and is the lead Center for coordinating the launch and mission support.

The NASA Aerospace Safety Research and Data Institute located at Lewis conducts research to supply safety technology, maintains a safety data bank and library, responds to requests for information, and provides consultation for NASA and the technical community.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

		1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
			(Thousands of Dollars)			
	FUNCTIONS					
I.	Personnel and Related Costs.....	$69,584	$69,598	$70,039	$71,833	$18,735
II.	Travel.....	1,063	1,065	994	1,074	316
III.	Facilities Services..	7,938	6,400	7,587	7,773	2,538
IV.	Technical Services...	356	432	486	406	144
V.	Administrative Support	917	943	815	816	203
Total, fund requirements...		$79,858	$78,438	$79,921	$81,902	$21,936

Distribution of Permanent Positions by Program

Over two thirds of Lewis' permanent positions are used in direct support of the various R&D programs. The following table summarizes actual and planned utilization of positions for direct program activity and for indirect support.

Direct Positions					
Manned Space Flight					
Space flight operations..	2	8	2	3	3
Space Sciences					
Launch vehicle procurement	212	230	213	213	213
Applications					
Space applications.....	117	100	148	106	106
Aeronautics and Space Technology					
Aeronautical research and technology.....	1,417	1,376	1,367	1,396	1,396

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Dollars in Thousands)			
Space and nuclear research and technology.....	659	740	549	561	561
Energy					
Energy technology applications.....	57	---	150	150	150
Technology Utilization.....	6	6	6	6	6
Subtotal, direct positions.....	2,470	2,460	2,435	2,435	2,435
Indirect Positions					
Director and staff.....	6	14	7	7	7
Administrative support.....	343	317	337	337	337
Research and development support.....	296	281	246	246	246
Subtotal, indirect positions.....	645	612	590	590	590
Total, permanent positions.	3,115	3,072	3,025	3,025	3,025
PERSONNEL AND RELATED COSTS					
I. PERSONNEL AND RELATED COSTS.....	$69,584	$69,598	$70,039	$71,833	$18,735

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
Basis of Fund Requirements					
A. Compensation and Benefits:					
1. Compensation					
a. Permanent positions...	$62,080	$61,755	$62,191	$63,936	$16,658
b. Nonpermanent positions...	336	571	615	622	180
c. Overtime and other compensation...	832	930	901	940	235
Subtotal, Compensation..	$63,248	$63,256	$63,707	$65,498	$17,073
2. Benefits.....	6,079	6,094	6,044	6,087	1,600
Subtotal, Compensation and Benefits.....	$69,327	$69,350	$69,751	$71,585	$18,673
B. Supporting Costs					
1. Transfer of personnel	$69	$68	$100	$60	$15
2. Personnel training.....	188	180	188	188	47
Subtotal, Supporting Costs.....	$257	$248	$288	$248	$62
Total, Personnel and Related Costs.....	$69,584	$69,598	$70,039	$71,833	$18,735
1. Compensation.....	$63,248	$63,256	$63,707	$65,498	$17,073
a. Permanent positions.....	$62,080	$61,755	$62,191	$63,936	$16,658

The difference between the 1975 budget estimate and the current estimate for 1975 is the cost of the October 1974 pay raise. This is partially offset by the savings resulting from a reduction in manpower from 3,072 to 3,025.

The increase in 1976 is due to the full year net effect of these actions.

Basis of Cost for Permanent Positions
(Thousands of Dollars)

In 1976 the cost of permanent positions will be $63,936, an increase of $1,745 from 1975. This increase results as follows:

Cost of permanent positions in 1975		$62,191
Cost increases:		+3,031
Within grade advances and career development		
Full Year effect of 1975 actions	+$487	
Partial year effect of 1976 actions	+523	
Full year effect of October 1974 pay raise and wage grade increases	+1,769	
Additional extra day	+252	
Cost decreases:		-1,286
Full year effect of 1975 manpower reductions	-$878	
Turnover savings		
Full year effect of 1975 actions	-118	
Partial year effect of 1976 actions	-290	
Cost of permanent positions in 1976		$63,936

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Dollars in Thousands)			
b. Nonpermanent Positions					
1. Cost	$336	$571	$615	$622	$180
2. Number of manyears	66	103	104	104	41

The 1976 program includes 104 positions to support the following programs:

Distribution of Nonpermanent Manyears by Program

	Manyears
College cooperative training	40
Summer employment	10
Opportunity programs	29
Other employment	25
Total	104

The current estimate for 1975 has been increased from the 1975 budget estimate due primarily to the October 1974 pay raise. The program for 1976 is planned at the same level as 1975.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
c. Overtime and other compensation.....	$832	$930	$901	$940	$235

The current estimate for 1975 reflects savings identified with final testing activities at the Plum Brook Station, partially offset by wage grade and general schedule pay raises. 1976 reflects the 1975 level of overtime and the full year cost of the pay raises.

2. Benefits	$6,079	$6,094	$6,044	$6,087	$1,600

The following table indicates the costs of personnel benefits by major categories:

Category of Cost					
Contribution to Civil Service Retirement Fund	$4,312	$4,323	$4,349	$4,465	$1,181
Contribution for life insutance.	211	217	211	209	55
Contribution for employee health insurance.....	833	715	1,134	1,358	350
Contribution to FICA.....	16	33	25	25	6
Incentive awards.	39	35	40	25	6
Other personnel benefits.....	4	2	5	5	2
Severance pay....	664	769	280	---	---
Total.....	$6,079	$6,094	$6,044	$6,087	$1,600

The current estimate for 1975 shows a decrease from the 1975 budget. This decrease results from the net effect of two actions. Retirements and attrition have been greater than anticipated thus reducing the size of the reduction-in-force associated with the closing of Plum Brook Station and decreasing the severance pay requirement. This savings in severance pay was partially offset by the increased cost of health benefits and the 20 percent increase in the government contribution to the Federal Health Benefits Program.

The increase in 1976 reflects the full year net cost of the above actions.

		1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
			(Thousands of Dollars)			
B.	Supporting Costs	$257	$248	$288	$248	$62
	1. Transfer of personnel.....	69	68	100	60	15

The increase in the current estimate over the 1975 budget reflects the cost of relocating personnel from Plum Brook Station to Cleveland. This relocation is a one-time requirement, and the 1976 estimate reflects a level of 15 moves as experienced in past years.

	2. Personnel training.....	$188	$180	$188	$188	$47

Approximately 38 percent of the training activity supports technically oriented training. Another 33 percent is provided specifically in the scientific and engineering fields. The remaining 29 percent supports administrative and clerical programs. 1975 and 1976 reflect the level of support experienced in 1974.

TRAVEL

II.	TRAVEL.....	$1,063	$1,065	$994	$1,074	$316

Over 75 percent of all Lewis travel is program related with major emphasis on support for the Centaur launch activities and research technology programs for aeronautics and space.

The current estimate for 1975 is reduced from the 1975 budget estimate to reflect the recent legislation limiting federal travel expenses. Travel requirements for 1976 are estimated at the 1975 level, and adjusted to take into account increased air fares.

Basis of Fund Requirements

Summary of Travel by Major Category

A.	Program Travel.....	$824	$770	$766	$828	$244
B.	Meetings and Technical Seminars.....	166	205	158	171	50
C.	Administrative Travel	73	90	70	75	22
	Total, Travel.....	$1,063	$1,065	$994	$1,074	$316

FACILITIES SERVICES

		1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
			(Thousands of Dollars)			
III.	FACILITIES SERVICES	$7,938	$6,400	$7,587	$7,773	$2,538

Basis of Fund Requirements

Summary of Facilities Services

A.	Maintenance and Related Services					
	1. Maintenance, repair and alteration of buildings and grounds.....	$1,775	$523	$1,267	$1,241	$340
	2. Custodial services....	1,749	1,617	1,694	1,711	573
	3. Maintenance of equipment...	142	105	102	107	30
	Subtotal.....	$3,666	$2,245	$3,063	$3,059	$943
B.	Operation of Facilities					
	1, Utilities.....	$3,735	$3,520	$4,431	$4,618	$1,565
	2. Supplies and equipment...	537	635	93	96	30
	Subtotal.....	$4,272	$4,155	$4,524	$4,714	$1,595
Total, Facilities Services.....		$7,938	$6,400	$7,587	$7,773	$2,538
A.	Maintenance and Related Services	$3,666	$2,245	$3,063	$3,059	$943
	1. Maintenance, repair, and alteration of buildings and grounds.....	$1,775	$523	$1,267	$1,241	$340

During the formulation of the 1975 budget, it was planned to continue a constrained maintenance program which essentially provided for only breakdown repairs. Since that time, a determination has been made that a preventive maintenance program is necessary in order to minimize repair costs in future years and the 1975 and 1976 estimates have been increased to reflect that program. This increased level of maintenance provides for electrical and equipment maintenance, maintenance of utilities systems, painting, and general building maintenance. The decrease in the 1975 and 1976 estimate from 1974 reflects the phased closing of Plum Book Station.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
2. Custodial services	$1,749	$1,617	$1,694	$1,711	$573

Custodial services provide for 155 manyears of effort to support the janitorial, security and rubbish services at both Cleveland and Plum Brook Station. Estimates for 1975 and 1976 reflect reduction from 1974 due to the placing of Plum Brook Station in a standby mode as planned in the 1975 budget estimate. An increase in the current estimate for 1975 is due to wage and price escalation. The 1976 estimate reflects the 1975 pricing level.

3. Maintenance and equipment.....	$142	$105	$102	$107	$30

The current estimate for 1975 has decreased based upon the lower cost for heavy equipment maintenance required in the phasing out of Plum Brook Station. 1976 reflects an increase for higher maintenance costs at Cleveland.

B. Operation of Facilities	$4,272	$4,155	$4,524	$4,714	$1,595
1. Utilities.....	$3,735	$3,520	$4,431	$4,618	$1,565

The increase in the current estimate for 1975 from the 1975 budget is due to a 46% increase in electrical power rates since 1974, which was not anticipated in the 1975 budget.

1976 reflects the full year cost of the 1975 increase.

2. Supplies and equipment.....	$537	$635	$93	$96	$30

The current estimate for 1975 decreases from the 1975 budget due to a major reduction in the purchase of mechanical, shop and general purpose facility equipment. All such equipment requirements in both 1975 and 1976 are being deferred to help offset the increased maintenance costs associated with buildings and grounds.

TECHNICAL SERVICES

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
IV. TECHNICAL SERVICES...	$356	$432	$486	$406	$144

Basis of Fund Requirements

Summary of Technical Services

A. Automatic Data Processing					
1. Equipment.....	$146	$236	$218	$137	$27
2. Programming and operations services.....	17	20	40	40	20
Subtotal.....	$163	$256	$258	$177	$47
B. Engineering Services.	$88	$122	$89	$90	$26
C. Scientific and Technical Informational and Educational Programs					
1. Educational /informational programs	$86	$37	$121	$121	$59
2. Scientific and technical information.....	19	17	18	18	12
Subtotal.....	$105	$54	$139	$139	$71
Total, Technical Services.	$356	$432	$486	$406	$144
A. Automatic Data Processing.....	$163	$256	$258	$177	$47

The current estimate for 1975 includes an increase in programming and operations support for the administrative computing requirements. This has been offset by a reduction in planned equipment purchases.

RPM 10-11

51-423 O - 75 - 52

The 1976 estimate is the same as 1975 for programming and operations, with a decrease in equipment purchases and rentals.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transtion Period
		(Thousands of Dollars)			
B. Engineering Services..	$88	$122	$89	$90	$26

The current estimate for 1975 has been reduced to the 1974 level. In 1976, the 1975 level of services will be maintained.

C. Scientific and Technical Information and Educational Programs	$105	$54	$139	$139	$71

The increase from the 1975 budget estimate to the 1975 current estimate is due to the recategorization of supplies and materials from the Administrative Support Functions in the amount of $75. The remaining increase is attributable to wage and price escalation.

1976 will continue at the 1975 level.

V. ADMINISTRATIVE SUPPORT	$917	$943	$815	$816	$203

Basis of Fund Requirements

Summary of Administrative Support

A. Communications					
1. Leased lines and long distance calls.....	$318	$309	$344	$338	$86
2. Local telephone service.....	282	160	228	225	55
3. Other communications.....	46	35	45	49	12
Subtotal.....	$646	$504	$617	$612	$153
B. Administrative Printing.....	$32	$78	$30	$30	$3
C. Supplies, Materials, and Equipment.....	$86	$148	$74	$79	$10

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
D. Transportation					
1. Center operations.	$35	$10	$28	$29	$6
2. Common carrier....	68	115	7	7	2
Subtotal.....	$103	$125	$35	$36	$8
E. Administrative Support Services.....	$50	$88	$59	$59	$29
1. Installation support.....	6	6	6	6	6
2. Occupational medicine and environmental health.....	44	82	53	53	23
Total, Administrative Support.....	$917	$943	$815	$816	$203
A. Communications.....	$646	$504	$617	$612	$153

Included in this function are services for local telephone service, FTS leased lines, as well as teletype service.

The current estimate for 1975 has increased from the 1975 budget due to increased rates for local service and the higher cost of leased lines and long distance calls.

1976 will continue at the 1975 level with a slight reduction in service associated with the closing of Plum Brook Station.

B. Administrative Printing	$32	$78	$30	$30	$3

The current estimate is less than the 1975 budget due to lower requirements for printing services.

The services for 1976 will continue at the 1975 level.

C. Supplies, Materials and Equipment.....	$86	$148	$74	$79	$10

The current estimate for 1975 is decreased from the 1975 budget due to the recategorization of $75 from this function to educational and informational programs.

The 1976 requirements for supplies and materials is estimated to be approximately the same level as 1975.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
D. Transportation.....	$103	$125	$35	$36	$8

The difference between the 1975 budget estimate and the current estimate is due to a reduction in the number of vehicle purchases. Recent analysis of transportation requirements has resulted in a decrease of 41 vehicles in the inventory operations.

The 1976 program is planned at the 1975 level.

E. Administrative Support Services.....	$50	$88	$59	$59	$29

The current estimate for 1975 is less than 1975 budget due to a delay in contracting for effluent sampling under the environmental health program. Development of sampling techniques will delay this work until 1976. The increase in 1976 as a result of the deferral is offset by the termination in medical services at Plum Brook Station.

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1976 ESTIMATES

NASA HEADQUARTERS

DESCRIPTION

The NASA Headquarters is located at 400 Maryland Avenue, S.W., Washington, D.C., and also occupies other buildings in the District of Columbia and nearby Virginia. Personnel primarily occupy Government-owned buildings.

MISSION

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. The principal statutory functions are:

1. To conduct research into, and for the solution of, problems of flight within and outside the earth's atmosphere and to develop, construct, test and operate aeronautical and space vehicles for research purposes.

2. To conduct activities required for the exploration of space with manned and unmanned vehicles.

3. To arrange for participation by the scientific community in planning scientific measurements and observations to be made through the use of aeronautical and space vehicles, and conduct or arrange for the conduct of such measurements and observations.

4. To provide for the widest practicable and appropriate dissemination of information concerning its activities and their results.

The following offices at Headquarters assist management in carrying out the technical aspects of this mission:

Office of Manned Space Flight - Responsible for the research, development and operations of manned space flight program including the scheduled Apollo Soyuz Test Project mission in mid-1975 and the Space Shuttle, the essential element of the space transportation system that will be used to conduct the space operations of the 1980's. The space transportation system consists of the Shuttle, a reusable manned vehicle; the Spacelab, an experiments payload carrier being developed by the Europeans; and an upper stage required for high energy missions beyond the basic Shuttle capabilities. An Interim Upper Stage will be developed by the U.S. Air Force to be followed later in the 1980's by a Space Tug.

Office of Space Science - Responsible for the NASA automated space flight program directed toward scientific investigations of the solar system utilizing ground-based, airborne, and space techniques including sounding rockets, earth satellites, and deep space probes; for scientific experiments to be conducted by man in space and for the scientific training of astronauts and for the development, procurement and use of light and medium class launch vehicles.

Office of Applications - Responsible for research and development activities leading to programs providing beneficial applications of space systems, the space environment, and space related or derived technology. Programs include investigation of weather and climate, pollution monitoring, earth resources surveys and earth and ocean physics applications; the use of the space environment for manufacturing; and the application of space developed technology to communications and other domestic problems.

Office of Aeronautics and Space Technology - Responsible for the planning, direction, execution, evaluation, documentation, and dissemination of the results of all NASA research and technology programs that are conducted primarily to demonstrate the feasibility of a concept, structure, component, or system which may have application to the nation's overall aeronautical and space objectives. This office is also responsible for coordinating the Agency's total program of supporting research and technology related to carrying out specific flight missions in order to avoid unnecessary duplication and to insure an integrated and balanced agency research program.

Office of Tracking and Data Acquisition - Responsible for the development, implementation, and operation of tracking, data acquisition, communications, and data processing facilities, systems, and services required for NASA flight programs. The office also has NASA-wide responsibility for administrative communications and frequency management.

The NASA Pasadena Office, Pasadena, California, is a component field activity of the NASA Headquarters. Its primary responsibilities are to negotiate and administer NASA contracts for the operation of the Jet Propulsion Laboratory and to provide patent and technology utilization services as they relate to prime and subcontracts at the Jet Propulsion Laboratory.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

Functions	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
I. Personnel and Related Costs.....	$43,455	$43,914	$45,008	$45,781	$13,683
II. Travel.....	2,433	2,615	2,299	2,465	701

Functions	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
III. Facilities Services..	447	4,240	4,037	4,105	1,100
IV. Technical Services...	11,034	10,647	10,271	10,561	2,786
V. Administrative Support.....	5,659	5,917	6,597	6,581	1,754
Total, fund requirements....	$63,028	$67,333	$68,212	$69,493	$20,024

Distribution of Permanent Positions by Program

The following table summarizes the actual and planned utilization of positions for direct program activity and for indirect support.

Direct Positions					
Manned Space Flight					
Space Shuttle.....	65	68	75	80	80
Space flight operations	123	129	109	104	104
Advanced missions.....	21	21	21	21	21
Space Science					
Physics and astronomy	57	78	56	56	56
Lunar and planetary exploration.....	38	52	37	37	37
Launch vehicle procurement.....	19	29	19	19	19
Applications					
Space applications...	99	94	97	97	97
Aeronautics and Space Technology.....					
Aeronautical research and technology.....	76	76	76	76	76
Space and nuclear research and technology.....	52	75	49	49	49

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
Energy Programs					
Energy technology applications.....	15	---	22	22	22
Tracking and Data Acquisition.....	46	52	45	45	45
Technology Utilization..	21	22	18	18	18
Subtotal, direct positions.....	632	696	624	624	624
Indirect Positions					
Administrator and staff.	165	178	163	163	163
Agency-wide management.	599	525	591	591	591
Headquarters administration.....	195	192	192	192	192
Subtotal, indirect positions.....	959	895	946	946	946
Total Positions.....	1,591	1,591	1,570	1,570	1,570

PERSONNEL AND RELATED COSTS

I. PERSONNEL AND RELATED COSTS.....	$43,455	$43,914	$45,008	$45,781	$13,683
Basis of Fund Requirements					
A. Compensation and Benefits:					
1. Compensation:					
a. Permanent positions...	$36,748	$37,429	$38,374	$38,393	$9,714
b. Nonpermanent positions...	994	703	709	726	242

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
1. Compensation:					
c. Reimbursable detailees	351	530	379	385	96
d. Overtime and other compensation....	166	224	235	239	60
Subtotal, Compensation.....	$38,259	$38,886	$39,697	$39,743	$10,112
2. Benefits	$4,465	$4,323	$4,518	$5,271	$3,295
Subtotal, Compensation and Benefits.....	$42,724	$43,209	$44,215	$45,014	$13,407
B. Supporting Costs:					
1. Transfer of personnel	$229	$270	$280	$280	$90
2. Civil Service Commission services.....	145	56	126	136	36
3. Personnel training...	357	379	387	351	150
Subtotal, Supporting Costs.....	$731	$705	$793	$767	$276
Total, Personnel and Related Costs.....	$43,455	$43,914	$45,008	$45,781	$13,683

Basis of Cost for Permanent Positions FY 1976
(Thousands of Dollars)

Cost of permanent positions in 1975.....		$38,374
Cost of increases in 1976.....		+1,548
Within grade advances and career development:		
Full year effect of 1975 actions.....	+$484	
Partial year effect of 1976 actions.....	+470	
Additional extra day in 1976.....	+145	
Full year effect of October 1974 pay raise.....	+449	
Cost decreases in 1976.....		-1,529
Full year effect of 1975 manpower reductions	-$1,001	
Turnover savings		
Full year effect of 1975 actions.....	-192	
Partial year effect of 1976 actions.....	-336	
Cost of permanent positions in 1976.....		$38,393

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
b. Nonpermanent Positions					
1. Cost	$994	$703	$709	$726	$242
2. Number of manyears	97	79	87	87	29

The 1976 estimate will support the following programs at approximately the levels indicated below:

Distribution of Nonpermanent Manyears by Program

	Manyears
College cooperative training	10
Summer employment	19
Opportunity programs	44
Other temporary employment	14
Total	87

The current estimate for 1975 increases from the 1975 budget estimate to reflect the cost of the October 1974 pay raise and a restructuring of the temporary employment program to place more emphasis on the Coop and opportunity programs while reducing the size of the summer program. The 1976 estimate reflects the full year cost of these actions.

c. Reimbursable Detailees	$351	$530	$379	$385	$96

The current estimate for 1975 is decreased from the 1975 budget estimate due to a reduction in the number of detailees from 20 to 14. The resulting savings is partially offset by the cost of the October 1974 pay raise. The increase in 1976 reflects the full year cost of the pay raise.

d. Overtime and other compensation	$166	$224	$235	$239	$60

The current estimate for 1975 is increased from the 1975 budget estimate due to the October 1974 pay raise. The increase in 1976 reflects the full year cost of the pay raise.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
2. Benefits.....	$4,465	$4,323	$4,518	$5,271	$3,295

The following table indicates the cost of personnel benefits by the major catetories:

Category of Cost					
Contribution to the Civil Service Retirement Fund.....	$2,552	$2,620	$2,655	$2,661	$693
Contribution for employee life insurance.....	132	138	137	139	35
Contribution for employee health insurance.....	336	290	451	577	126
FICA.....	39	43	42	44	15
Incentive awards.....	52	51	52	53	13
Workmen's compensation..	1,266	1,181	1,181	1,797	2,413
Severance pay.....	88	---	---	---	---
Total.....	$4,465	$4,323	$4,518	$5,271	$3,295

The current estimate for 1975 has increased over the 1975 budget due to the large increase in the cost of health benefits services. In addition, there was a 20% increase in the Government's contribution to the Federal Health Benefits Program effective January 1975. The increase in 1976 reflects the full year cost of these actions and the higher cost of workmen's compensation funded by NASA Headquarters for the entire agency, which represents amounts for which NASA has been billed by the Labor Department pursuant to law.

B. Supporting Costs.....	$731	$705	$793	$767	$276

Supporting Personnel Costs provide for the expense of moving employees to a new duty station, for Civil Service Commission services which are funded by NASA Headquarters for the entire agency, and for the training of employees.

1. Transfer of personnel.....	$229	$270	$280	$280	$90

The 1975 and 1976 program remains essentially constant, providing for 28 moves each year. Both the current estimate for 1975, and the 1976 estimate, however, reflect the increased cost associated with moving expenses.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
2. Civil Service Commission services.....	$145	$56	$126	$136	$36

The current estimate for 1975 is increased from the 1975 budget estimate due primarily to the cost of Equal Employment Opportunity (EEO) investigations. The increase in 1976 provides for the higher cost of services provided by the Civil Service Commission. These services include investigations, recruitment, advertising, career maturity surveys, and discrimation complaint investi-gations.

3. Personnel Training.....	$357	$379	$387	$351	$150

The current estimate for 1975 is increased from the 1975 budget estimate due to the higher cost of tuition, with no change in the level of training activity. The decrease in 1976 reflects a reduction in the number of contractual training programs.

TRAVEL

II. TRAVEL.....	$2,433	$2,615	$2,299	$2,465	$701

Approximately 37% of the travel funds are used in direct support of NASA's research and development programs, such as the Space Shuttle, the Viking mission to Mars, and the Apollo Soyuz Test Project. Additional requirements include travel by unpaid members of research advisory committees, travel by NASA officials to national and international conferences and working panels, and travel by NASA management to the field installations reporting to NASA Headquarters to review center requirements and operations to assure agency policies and procedures are being implemented properly throughout the agency.

The current estimate for 1975 is decreased from the 1975 budget estimate to reflect the recent legislation limiting federal travel expenses. Travel requirements for 1976 are estimated at the 1975 level, and adjusted to take into account increased air tariffs.

Summary of Travel by Major Category

A. Program travel.....	$856	$888	$855	$925	$270
B. Meetings and Technical seminars...	807	911	713	771	223
C. Administrative travel..	770	816	731	769	208
Total, Travel.....	$2,433	$2,615	$2,299	$2,465	$701

FACILITIES SERVICES

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
III. FACILITIES SERVICES....	$447	$4,240	$4,037	$4,105	$1,100
Basis of Fund Requirements					
Summary of Facilities Services					
A. Rental of Real Property	$52	$3,993	$3,585	$3,643	$983
B. Maintenance and Related Services					
1. Maintenance of buildings and grounds.....	$227	$108	$300	$300	$75
2. Maintenance of equipment	9	9	3	3	1
3. Custodial services.....	124	128	145	155	40
Subtotal.....	$360	$245	$448	$458	$116
C. Operation of Facilities					
1. Supplies and equipment	$35	$2	$4	$4	$1
Total, Facilities Services.....	$447	$4,240	$4,037	$4,105	$1,100
A. Rental of Real Property...	$52	$3,993	$3,585	$3,643	$983

The current estimate for 1975 is decreased from the 1975 budget estimate due to a reduction in the rates charged by the General Services Administration for the building space which houses NASA Headquarters. The increase in 1976 reflects the relocation of the NASA Scientific and Technical Information Facility (STIF) from its current location in College Park, Maryland to facilities at Baltimore Washington International Airport.

B. Maintenance and Related Services.....	$360	$245	$448	$458	$116
1. Maintenance of buildings and grounds.....	$227	$108	$300	$300	$75

The current estimate for 1975 is increased from the 1975 budget estimate due primarily to the cost of rearranging office space for better utilization and to accommodate the organizational realignments recently effected at NASA Headquarters.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
2. Maintenance of equipment.....	$9	$9	$3	$3	$1

The current estimate for 1975 is decreased from the 1975 budget estimate due to transfer of security alarm maintenance responsibility from a NASA contractor to the General Services Administration (GSA) with a resulting reduction in costs for the same level of service. The 1976 estimate provides for the same level of service as 1975.

3. Custodial services.....	$124	$128	$145	$155	$40

The current estimate for 1975 is increased from the 1975 budget estimate due to the higher cost of GSA-supplied guard services and the addition of one more guard. The increase in 1976 provides for the full year cost of the increased hourly rate and the additional guard.

C. Operation of Facilities...	$35	$2	$4	$4	$1

The current estimate for 1975 is increased from the 1975 budget estimate to cover replacement of outdated medical equipment in the Headquarters Health Unit.

TECHNICAL SERVICES

IV. TECHNICAL SERVICES....	$11,034	$10,647	$10,271	$10,561	$2,786

Basis of Fund Requirements

Summary of Technical Services

A. Automatic Data Processing					
1. Equipment.....	$1,010	$1,121	$1,042	$1,354	$336

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
2. Programming and operation services	2,082	1,783	1,889	1,811	455
Subtotal.....	$3,092	$2,904	$2,931	$3,165	$791
B. Engineering Services...	$14	$57	$67	$140	$36
C. Scientific and Technical Information and Educational Programs					
1. Operation of NASA technical libraries	$48	$49	$52	$56	$16
2. Educational/informational programs...	2,070	1,990	2,052	1,835	484
3. Scientific and technical information.	5,810	5,647	5,169	5,365	1,459
Subtotal.....	$7,928	$7,686	$7,273	$7,256	$1,959
Total, Technical Services.....	$11,034	$10,647	$10,271	$10,561	$2,786
A. Automatic Data Processing.....	$3,092	$2,904	$2,931	$3,165	$791

The current estimate for 1975 is increased from the 1975 budget estimate. This is the net effect of contract wage increases and postponing the acquisition of new computer equipment because of more urgent fund requirements in other areas.

The increase in 1976 reflects the planned procurement of additional computer storage and data processing capability required to meet operational requirements. This is partially offset by a reduction in the level of contract support.

B. Engineering Services... $14 $57 $67 $140 $36

The current estimate for 1975 is increased from the 1975 budget estimate to provide for publishing a Semi-Conductor Experience Handbook, which was not included in the 1975 budget. The 1976 increase is to provide for studies into the expanding field of semi-conductors; preparation of NASA-Wide Safety, Reliability and Quality Assurance Standards; and costs associated with compliance with the Occupational Safety and Health Act.

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
C. Scientific and Technical Information and Educational Programs.....	$7,928	$7,686	$7,273	$7,256	$1,959

Included in these programs are the costs of the technical libraries, educational/informational programs, and the scientific and technical information services. The costs are summarized as follows:

1. Operation of technical libraries.....	$48	$49	$52	$56	$16

The current estimate for 1975 is increased from the 1975 budget estimate due to higher prices for books, subscriptions, pamphlets, and other periodicals for the NASA Headquarters Technical Library. The increase in 1976 reflects the full year cost of these increases.

2. Educational/informational programs..	$2,070	$1,990	$2,052	$1,835	$484

The current estimate for 1975 is increased from the 1975 budget estimate due to higher costs for motion picture services. The 1976 estimate reflects a reduction in the level of activity for exhibit and news services.

3. Scientific and technical information.....	$5,810	$5,647	$5,169	$5,365	$1,459

The current estimate for 1975 is decreased from the 1975 budget estimate to reflect the realignment of the support contract funding plan for operation of the NASA Scientific and Technical Information Facility (STIF). The increase in 1976 is due primarily to contract wage increases partially offset by a reduction in the level of contractor support.

V. ADMINISTRATIVE SUPPORT.....	$5,659	$5,917	$6,597	$6,581	$1,754

Basis of Fund Requirements

Summary of Administrative Support

A. Communications					
1. Leased lines and long distance tolls.....	$628	$697	$549	$561	$142

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
2. Local telephone services.....	317	425	425	400	100
3. Other communications.	1,710	2,354	2,336	2,243	618
Subtotal.....	$2,655	$3,476	$3,310	$3,204	$860
B. Administrative Printing.....	$394	$324	$398	$405	$102
C. Supplies, Materials, and Equipment.....	$731	$411	$806	$877	$230
D. Transportation					
1. Center operations....	$84	$85	$105	$126	$32
2. Common carrier.....	22	18	10	25	5
Subtotal.....	$106	$103	$115	$151	$37
E. Administrative Support Services					
1. Installation support services.....	$1,587	$1,407	$1,767	$1,741	$472
2. Medical services.....	186	196	201	203	53
Subtotal.....	$1,773	$1,603	$1,968	$1,944	$525
Total Administrative Support.....	$5,659	$5,917	$6,597	$6,581	$1,754
A. Communications	$2,655	$3,476	$3,310	$3,204	$860

The current estimate for 1975 is decreased from the 1975 budget estimate due to a reduction in the NASA Headquarters share of the Agency's bill for Federal Telecommunications System (FTS) lines. The reduction in 1976 is due primarily to an estimated decrease in the number of Agency mailings, thereby reducing the postal costs which are funded by NASA Headquarters for the entire Agency.

51-423 O - 75 - 53

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Thousands of Dollars)			
B. Administrative Printing...	$394	$324	$398	$405	$102

The increased current estimate for 1975 over the budget estimate reflects increased printing costs. The 1976 estimate provides for the full year cost of the increases.

C. Supplies, Materials and Equipment.....	$731	$411	$806	$877	$230

The current estimate for 1975 is increased from the 1975 budget estimate to reflect current operating requirements. The increase in 1976 is to provide for updating the avionics equipment on the administrative aircraft.

D. Transportation.....	$106	$103	$115	$151	$37

The current estimate for 1975 is increased from the 1975 budget estimate due primarily to higher contract costs for maintenance of the JPL administrative aircraft, which is funded by the NASA Pasadena Office. The 1976 increase reflects the contract cost of installation of FAA required avionics equipment in the JPL administrative aircraft and the cost of charter service while the aircraft is down for this installation, as well as the increased cost for freight, express and drayage at NASA Headquarters.

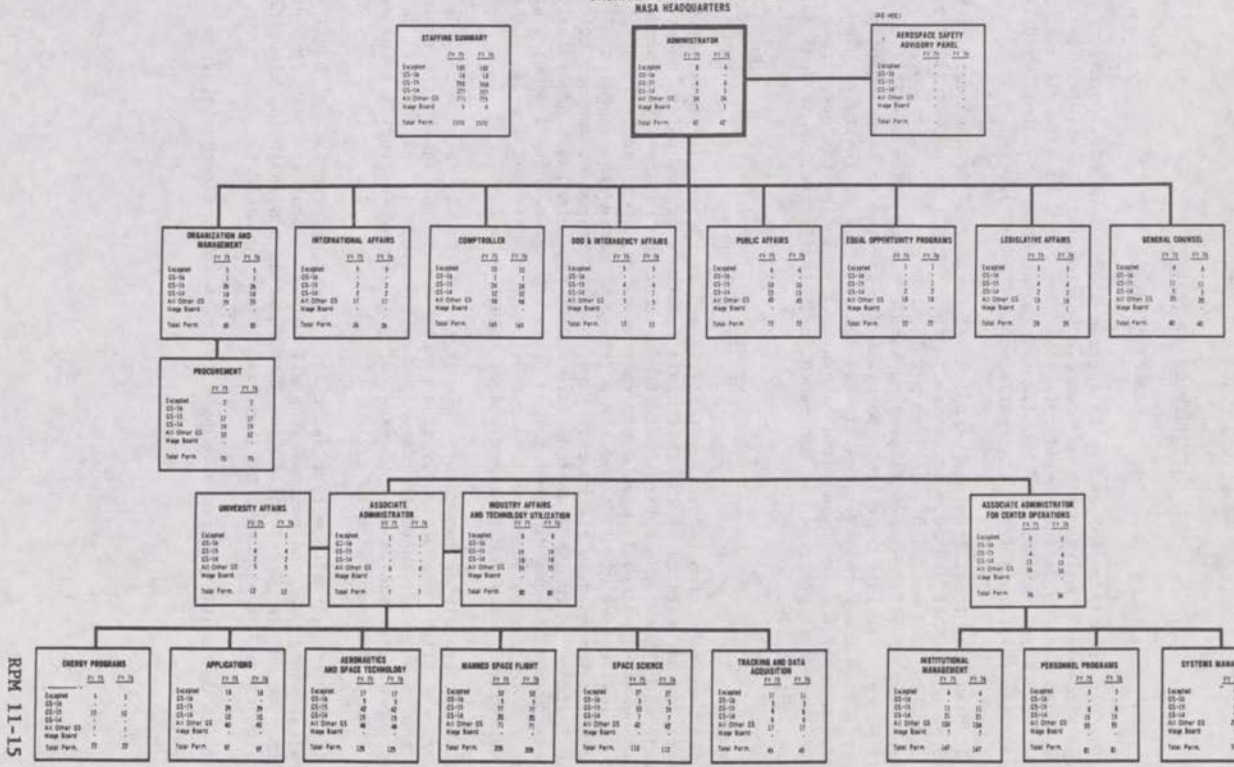
E. Administrative Support Services.....	$1,773	$1,603	$1,968	$1,944	$525

The current estimate for 1975 is increased from the 1975 budget estimate to provide for Equal Employment Opportunity and Minority Business programs which were not included in the 1975 Budget. In addition, it reflects the increased assessment for NASA's share of the cost of the Civil Service Commission Information Center and for increases in the cost of contract labor services and printing plant maintenance. The 1976 estimate provides for continuing the 1975 level of activity adjusted for the phasedown in requirements for Russian language interpreters in the connection with completion of the Apollo Soyuz Test Project.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORGANIZATION AND STAFFING

NASA HEADQUARTERS



RPM 11-15

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1976 ESTIMATES

JET PROPULSION LABORATORY

DESCRIPTION

The Jet Propulsion Laboratory is located in Pasadena, California, approximately 20 miles north of downtown Los Angeles. Subsidiary facilites 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 145.9 acres are owned by NASA and 30.9 acres are leased. At Goldstone, facilities are located on land occupied under the 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, 1974, was $362,526,000.

MISSION

The Jet Propulsion Laboratory (JPL) 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 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 information only, and are not a part of the NASA Research and Program Management budget request.

The Jet Propulsion Laboratory is engaged principally in research, development, and flight project activities connected with the scientific exploration of the planets and interplanetary space with automated spacecraft. This assignment encompasses a broad range of engineering, scientific, and management functions devoted to:

1. The conduct of complete space flight projects, including overall project management and encompassing all phases of project activity beginning with mission design and scientific justification and following with spacecraft design, development, testing, and flight operations.

2. A continuing program of supporting research and technology.

3. The development, implementation, and operation of the Deep Space Network which provides tracking and data acquisition support for all NASA projects involving flights at planetary and interplanetary distances.

Planetary Exploration - The Mariner series of spacecraft was designed and developed by the Jet Propulsion Laboratory, and the Laboratory has had project management responsibility for all Mariner missions, including the functions of integration, assembly, and testing of the spacecraft. The two most recent missions in the Mariner series are Mariners 9 and 10.

Mariner 9 was placed in orbit about Mars in November 1971.

The Mariner 10 spacecraft was launched in October 1973, and employed the gravity-assist technique to perform successful flybys of both Venus and Mercury during February and March, respectively, of 1974.

The Mariner 10 mission is the first to explore the planet Mercury. The mission is still in progress with the spacecraft operating well and on a flight path which will take it near Mercury again for a third time in March 1975.

The Laboratory is also involved as a major participant in the Viking project which will launch two flights to Mars in mid-1975. Each flight will employ a spacecraft consisting of an orbiter and a lander. The NASA Langley Research Center has overall management responsibility for the Viking project and for development of the lander. JPL has responsibility for the development of the orbiter, for the tracking and data acquisition system, and for the mission control and computing center.

In the continuing series of Mariner missions, the Jet Propulsion Laboratory has management responsibility for the Mariner Jupiter/Saturn 1977 mission, which involves two launches in 1977. At that time the relative positions of Jupiter and Saturn are uniquely favorable for the utilization of gravity-assist techniques which will permit the spacecraft in passing near Jupiter to be accelerated to reach Saturn in the relatively short time of 3.5-4 years.

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, materials and structures, space power and electric propulsion, chemical propulsion, electronics, and basic research in such fields as fluid physics, polymer materials, and applied mathematics. In addition, 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 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, implementation, maintenance, and operation of NASA's worldwide Deep Space Network. 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 at planetary and interplanetary distances.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

		1975			
	1974	Budget Estimate	Current Estimate	1976	Transition Period
	(Thousands of Dollars)				
I. Personnel and Related Costs.....	$78,750	$80,496	$84,161	$90,648	$24,508
II. Travel.....	2,704	2,502	2,994	3,089	927
III. Facilities Services..	6,141	6,467	7,380	7,982	2,135
IV. Technical Services...	2,037	1,332	2,145	2,210	591
V. Administrative Support.....	8,051	7,676	8,756	9,099	2,434
Total, Fund Requirements...	$97,683	$98,473	$105,436	$113,028	$30,595

Distribution of Permanent Positions by Program

Direct Positions

Manned Space Flight

Space shuttle.....	4	11	7	9	9
Space flight advanced missions.....	6	5	5	5	5
Apollo.....	12	1	3	---	---

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
Space Science					
Physics and astronomy.....	19	16	15	16	16
Lunar and planetary exploration.....	1,134	1,060	1,065	1,027	1,027
Launch vehicle procurement.....	7	9	4	4	4
Applications					
Space applications.....	66	73	113	139	139
Aeronautics and Space Technology					
Aeronautical research and technology.....	45	13	27	14	14
Space and nuclear research and technology.....	203	237	193	218	218
Tracking and Data Acquisition.....	332	342	341	350	350
Technology Utilization.....	10	---	23	24	24
Energy Programs					
Energy technology applications.....	---	---	35	25	25
Subtotal, direct positions	1,838	1,767	1,831	1,831	1,831
Direct support.....	667	703	622	622	622
Indirect positions.....	1,248	1,186	1,203	1,203	1,203
Total positions.....	3,753	3,656	3,656	3,656	3,656

Personnel and Related Costs - The increase in the 1975 current estimate over the 1975 budget estimate, and the increase in the 1976 estimate are a result of cost of living and merit increases for permanent and nonpermanent personnel, plus increased overtime associated with the Viking project. Personnel benefits increased as a result of broader participation in the Teacher Insurance and Annuity (TIAA) retirement plan, and an increase in the FICA base. An increase in supporting personnel costs is associated with moving personnel.

Travel - The increase in the 1975 current estimate over the 1975 budget estimate is a result of higher airline fares, per diem and lodging costs. The increase in 1976 reflects the full year cost of the higher airline fare, per diem and lodging costs.

Facilities Services - The increase in the 1975 current estimate over the 1975 budget estimate and the increase in the 1976 estimate are a result of higher utility costs, and price increases for supplies and equipment and wage increases for maintenance and related services. Another factor affecting the increase in 1976 is the requirement to lease off-site temporary space to house equipment and personnel temporarily displaced by Langley and contractor personnel associated with the Viking project.

Technical Services - As a result of the determination that Electronic Parts Stores is properly an element of the simulated R&PM budget, this function now includes funding for that item for the first time. Electronic Parts Stores was not included in the 1975 budget estimate. The 1975 current estimate and the 1976 budget estimate, however, provides funding for Electronic Parts Stores which accounts for the major part of the increase. Additional increases are in other Engineering services, Automatic Data Processing (ADP) services and equipment, and scientific and technical information.

Administrative Support - As a result of the determination that the administrative costs associated with the Goldstone, California facility is properly an element of the simulated R&PM budget, this function now includes funding for these costs for the first time, and as a result, were not included in the 1975 budget estimate. The 1975 current estimate and the 1976 budget estimate, however, provides funding for these costs which accounts for the major part of the increase. Additional increases are in other administrative costs, communication, printing and reproduction, supplies, material and equipment and transportation.

Transition Period - The transition period estimate represents a continuation of the rate normally experienced during the first quarter of a fiscal year.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1976 AND TRANSITION PERIOD ESTIMATES

SUMMARY OF AERONAUTICAL RESEARCH AND TECHNOLOGY
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

	1974	1975 Budget Estimate	1975 Current Estimate	1976	Transition Period
		(Millions of Dollars)			
Research and development.	$168.0	$166.4	$166.4	$175.4	$46.8
Construction of facilities.....	2.4	9.7	9.7	4.6	---
Research and program management.....	132.9	135.1	132.4	134.2	37.0
Total.....	$303.3	$311.2	$308.5	$314.2	$83.8
Number of direct positions (end of year) associated with aeronautical research and technology.....	3,861	3,899	3,786	3,849	3,849

The Aeronautics program for FY 1976 and the transition period will advance aeronautical technology to ensure safer, more economical air transportation systems which are responsive to current and future needs; provide the United States with a strong competitive position in the international market place; and provide technical support to the military in maintaining the superiority of the nation's military aircraft.

Fundamental research in the disciplines of materials, structures, avionics, aerodynamics, propulsion, and man-vehicle interactions will continue in FY 1976 and the transition period to provide the solid technology base necessary to stimulate and meet the future requirements of civil aviation. Special emphasis will be given to reducing aircraft energy consumption and the undesirable environmental effects of noise and atmospheric pollution. The effort is directed at providing the technology for quiet, clean and efficient propulsion systems; the application of active control concepts; advanced materials and structural concepts to reduce aircraft weight; the reduction of aerodynamic drag; and the evaluation of candidate non-petroleum-based fuels for use in aircraft. The program will include a strong effort aimed at improving terminal area operations and safety through the development of technology to improve avionics, control systems, operating

procedures, crashworthiness, and the fire resistance of aircraft interior materials. An additional focused technology effort will develop technology for advance long-haul and short-haul air transportation system concepts for the future. The short-haul program addresses short take-off and landing (STOL), vertical take-off and landing (VTOL) and rotorcraft systems; while the long-haul program addresses conventional take-off and landing (CTOL) and subsonic systems with a modest effort aimed at developing supersonic and hypersonic technology to provide options for aircraft of the future.

The aeronautics program supports the military by providing an advanced technology base which is applicable to military aircraft as well as civil aircraft, and by providing technical problem solving support for current military aircraft development.

The construction of facilities request for FY 1976 includes funding for an addition for composite model and metal finishing shops at the Langley Research Center and modifications of the 11- x 11- feet transonic wind tunnel 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 support the aeronautics program.

RESEARCH AND DEVELOPMENT

ESTIMATED FY 1976 OBLIGATIONS FOR
EQUIPMENT TO BE PLACED AT NASA INSTALLATIONS

Program Budget Line Item	(Thousands of Dollars) 1976
Manned Space Flight	$ 99,280
Space Shuttle	(82,157)
Development, Test and Mission Operations	(15,139)
Mission Systems and Integration	(1,634)
Space Life Sciences	(350)
Space Science	7,456
Lunar and Planetary	(3,809)
Physics and Astronomy	(2,530)
Launch Vehicle Procurement	(1,117)
Space Applications	8,349
Aeronautics and Space Technology	39,970
Aeronautical Research and Technology	(32,991)
Space and Nuclear Research and Technology	(6,979)
Tracking and Data Acquisition	10,522
GRAND TOTAL	$165,577

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1976 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1976 OBLIGATIONS ($ in Thous.)	RELATED FACILITY PROJECT
Space Shuttle	Johnson Space Center Bldg. 35, 72-76-01	Shuttle Procedures Simulator System (SPS). The SPS is being developed by modifying the Apollo Procedures Simulator by the addition of the Shuttle Type crew station with cockpit instrumentation.	To establish and evaluate the crew's man-machine interface, develop, and validate crew procedures, and provide part task training for related mission phases.	500	
Space Shuttle	Johnson Space Center Bldg. 5, 72-76-02	Orbiter Aeroflight Simulator (OAS). The OAS will be developed by utilizing equipment from the Apollo mission simulators and adding a motion base, Shuttle Orbiter Crew Station, visual display system and Instructor's console.	To support the horizontal flight test phase of the Shuttle Program by providing training for flight crews and ground controllers.	4,400	
Space Shuttle	Johnson Space Center Bldg. 5, 72-76-03	Shuttle Mission Simulator (SMS). The SMS will operate in conjunction with the mission control center and will consist of a computer complex, crew station, visual simulator equipment, the motion base and the Instructor's console.	To train flight crews and ground controllers in the operation of all spacecraft systems in the launch, orbital, deorbit, entry, terminal, and landing phases of the Shuttle Program.	6,200	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1976 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1976 OBLIGATIONS ($ in Thous.)	RELATED FACILITY PROJECT
Space Shuttle	Marshall Space Flight Center Bldg. 4610 62-76-01	Hydraulic loading and load control system for structural test facility.	Required to apply loads to structurally test Shuttle Solid Rocket Booster elements.	1,100	
Space Shuttle	Kennedy Space Center (various bldgs.) 76-76-01	The Launch Processing System and associated equipment.	Test, checkout and launch of spacecraft and launch vehicles stages requires the transmission of command, and information regarding the status and the performance of flight systems, subsystems and their associated ground support systems.	21,414	
Development, Test, and Mission Operations	Johnson Space Center Bldg. 16 72-76-06	Digital Computer System	To accomplish the guidance and control systems tasks in support of the Shuttle	655	
Development, Test, and Mission Operations	Marshall Space Flight Center Bldg. 4708 62-76-03	Computer System	Required for data systems development in support of Spacelab	573	

51-423 O - 75 - 54

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1976 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1976 OBLIGATIONS ($ in Thous.)	RELATED FACILITY PROJECT
Mission Systems and Integration	Marshall Space Flight Center (bldg. not identified) 62-76-06	Concept Verification Test Simulators Hardware	Spacelab Simulator/ Shuttle Interface Simulator structural components for integration into the CVT simulators.	1,400	
Aeronautical Research and Technology	Ames Research Center Bldg. 210 21-76-01	Digital Computer Systems for Simulators	Required for the replacement of 10 year old computer systems.	1,103	
Aeronautical Research and Technology	Ames Research Center Wind Tunnel Bldgs. 21-76-02	Pressure Transducer system includes a high performance pressure transducer and readout, necessary cables and data acquisition system interface.	Required to replace existing electro-mechanical manometer followers. The resulting improved reliability and decreased pressure settling time will significantly improve facility operational efficiency.	250	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1976 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1976 OBLIGATIONS ($ in Thous.)	RELATED FACILITY PROJECT
Aeronautical Research and Technology	Ames Research Center Wind Tunnel bldgs. 21-76-03	Electronic strain gage signal conditioning and raw data display equipment.	Required to replace existing obsolete equipment in seven wind tunnels.	275	
Aeronautical Research and Technology	Ames Research Center Bldg. N-227 21-76-04	Dedicated digital computer and control system.	The existing data input/ output rate of computers serving the Unitary Wind Tunnels is not fast enough to handle all static and dynamic problems in real time.	250	
Aeronautical Research and Technology	Ames Research Center Bldg. N-227 21-76-05	Forced Oscillation Semispan Model Support System and Associated Instrumentation	Required to conduct investigations of unsteady aerodynamics at transonic speeds.	250	
Aeronautical Research and Technology	Ames Research Center Bldg. 221-J 21-76-06	Data Acquisition System consisting of a master computer, card reader, disk drivers with controllers, magnetic tape drives with controllers, incremental plotter, line printer, paper tape reader and punch and input/output interfaces.	Required to replace outdated computer in 40'x80' wind tunnel.	586	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1976 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1976 OBLIGATIONS ($ in Thous.)	RELATED FACILITY PROJECT
Aeronautical Research and Technology	Ames Research Center Bldg. N-210 21-76-07	Data Acquisition System consisting of telemetry and RADAR front end data acquisition equipment.	Required to conduct safe, efficient, and economical flight test. Provide back-up redundancy and process increased flight data requirements.	500	
Aeronautical Research and Technology	Ames Research Center Bldg. 233 21-76-08	Large-scale computer for Ames central computer facility.	Required in the development of large scale aerodynamics codes and for support of other research activities at Ames.	1,440	
Aeronautical Research and Technology	Ames Research Center Bldg. 233 21-76-09	A high speed printer/plotter computer output microfilm system.	Required to produce plotted and printed output and microfilm records from computer output.	300	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1976 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1976 OBLIGATIONS ($ in Thous.)	RELATED FACILITY PROJECT
Aeronautical Research and Technology	Langley Research Center Bldg. 643 23-76-01	Heavy duty strut and turntable model support system.	Required to increase testing time. Load carrying capability will be increased to 10,000#.	350	
Aeronautical Research and Technology	Langley Research Center Bldg. 640 23-76-02	Model Support System	Will provide for five separate remotely controlled model motions.	450	
Space and Nuclear Research and Technology	Ames Research Center (unidentified bldg.) 21-76-10	Spacelab Airborne Simulator	Required to develop operational concepts for managing Spacelab payloads.	400	
Physics and Astronomy	Ames Research Center Bldg. N-248-1 21-76-12	Environment Control System for the C-141 Airborne Observatory	Required to protect the AIRO Telescope System on the C-141 Aircraft.	450	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1976 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1976 OBLIGATIONS ($ in Thous.)	RELATED FACILITY PROJECT
Tracking and Data Acquisition	GSFC, Space Operations Facility Bldg. 14 51-76-01	HEAO Control Center System. Provides control and mission operations consoles with CRT displays.	Required to conduct real-time operations and control of the HEAO spacecraft.	$ 500	
Tracking and Data Acquisition	GSFC, Spacecraft Operations Facility Bldg. 14 51-76-02	IUE Control Center System. Provides control and display consoles for spacecraft and experiment operations.	Required to conduct the real-time operations of the International Ultraviolet Explorer spacecraft	700	
Tracking and Data Acquisition	GSFC, Data Interpretation Lab. Bldg. 23 51-76-03	Digital Image Processing System. Provides a high precision digital processing capability to handle image data received from various NASA missions.	Required to augment present system to provide increased image accuracy and precision in support of missions such as NIMBUS-G, HCMM, SEASATS	2500	
Tracking and Data Acquisition	Jet Propulsion Lab Combined Electronics Bldg. 125 55-76-01	Tracking Cross-Correlator. Provides a correlation system for processing tracking data from two widely separated stations.	Outer planet spacecraft require increased precision in ground navigation. Very Long Baseline Interferometric (VLBI) techniques will be utilized by Deep Space Network stations to achieve the required accuracy.	455	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1976 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1976 OBLIGATIONS ($ in Thous.)	RELATED FACILITY PROJECT
Tracking and Data Acquisition	Jet Propulsion Lab Plant Engineering Bldg. 202 55-76-02	Deep Space Network Control Support Processor, with Peripherals. Provides a continuation of a lease initiated in FY75.	Temporary augmentation of existing on-line network control equipment to provide continuity of support to on-going Pioneer and Viking missions while conducting software development for future approved spacecraft.	$ 252	
Tracking and Data Acquisition	Flight Research Center Laboratory Bldg. 4800 24-76-01	Telemetry Ground Station System Augmentation. Provides small computer to increase telemetry data handling capacity in existing system.	Current program schedules require ground support for two major aeronautical programs on the same day. This equipment augmentation permits a more rapid change-over by making software rather than hardware changes.	300	
Tracking and Data Acquisition	GSFC, Central Flight Control and Range Operations Bldg. 3 51-76-04	Network Data Processor, including processing and disc stowage units. Provides more effective utilization of existing large-scale computers by pre-processing incoming data to relieve the high speed computer of editing functions.	Existing data volume is saturating the high speed computers, and will increase. More efficient utilization of the large computers directly in their principal function (data processing) will be possible with the addition of this front-end processor.	685	

TRANSFER AUTHORITY

Mr. BAUCUS. NASA requested $749,624,000 for fiscal year 1975. That was reduced to $740 million by the Congress. As you know, a provision was made to allow a transfer up to one fourth to 1 percent from the R. & D. appropriation to the R. & P.M. appropriation. According to page SUM 3, it appears you have elected to use $5.2 million of that transfer authority, leaving about $600,000. We are wondering if NASA will use the remaining transfer authority?

Mr. GROO. We will not use the remainder, Mr. Chairman.

Mr. BAUCUS. On the same page, it is apparent that you are requesting $19,975,000 as part of the supplemental to cover the effects of the October 1974 civil service pay raise. Are you absorbing any of the $19,975,000 required to cover the October 1974 pay increase?

Mr. GROO. No, sir, we have no plans to try to absorb that.

Mr. BAUCUS. Have you tried?

Mr. GROO. We have efforts going on which will result in certain reductions in personnel costs for fiscal year 1975. However, in order to cover the cost of the October 1974 pay raise, we will need the $19,975,000 supplemental appropriation in fiscal year 1975.

Mr. BAUCUS. Did OMB ask you to try to absorb any of it?

Dr. LOW. Yes; it was reviewed. It is a standard procedure to try to see what can be absorbed.

Mr. LILLY. We are not able to absorb the impact of the October 1974 pay raise. However, we did absorb about $1.8 million of wage increases on blue collar pay that gets adjusted periodically.

Mr. BAUCUS. So you did absorb about $2 million?

Mr. LILLY. Yes; that absorption was for blue-collar worker pay adjustments, not for the Civil Service General Schedule pay raise.

REASONS FOR INCREASES

Mr. BAUCUS. What that means then, with the transfer and the supplemental request, is that the current fiscal year 1975 R. & P.M. estimate is $765,175,000 and the fiscal year 1976 request is $776,000,000 or a $10.8 million increase.

At the bottom of page SUM 2, the justifications suggest that most of this $10 million is attributable to utility costs.

Is that correct?

Mr. GROO. Most of the increase in fiscal year 1976 is attributable to the full-year personnel costs of the October 1974 pay raise. Some of it is attributable to increased utility costs. There is $2 million additional cost for utilities.

There are also some increases in air fares which affect travel. However, the principal element of the increase is in terms of personnel costs.

In personnel and related costs, there is a net of $5.6 million, comprised of $8 million for the full-year effect of the October 1974 pay raise, $10.1 million for promotions and within-grade increases, and $2.3 million for the additional payday in fiscal year 1976. These increases are partially offset by a $14.8 million savings related to the full-year effect of the 704-position reduction in fiscal year 1975 and turnover savings to be achieved in fiscal year 1976.

AIR FARE INCREASES

Mr. BAUCUS. How much for air fare increases?

Mr. GROO. $1,128,000.

Mr. BAUCUS. When were the general increases effective?

Mr. GROO. This is based in part upon increases in April, October, and November 1974, and our estimates for 1975 and 1976.

Mr. BAUCUS. What percentage increase in rates do you expect?

Mr. GROO. The cumulative percentage increase in rates will be, we anticipate, over 12 percent with an effect on our budget of approximately 8 percent because it will not take place at the beginning of the fiscal year.

Mr. BAUCUS. What if there is no increase?

Mr. GROO. Then we will reduce our travel expenditures.

Dr. LOW. We are doing about half as much travel as we did a few years ago, because the costs of travel have increased much faster than our budget has increased. Even if this rate increase does not materialize, we will be very tight on travel funds.

Mr. ROUSH. I have read lately that the costs of the longer trips are going down instead of up. Isn't that correct?

Mr. LILLY. There have been some petitions on that subject that I have seen in the newspapers, Mr. Roush.

Mr. ROUSH. Have you considered that?

Mr. GROO. We have considered may ways to cut down on travel costs, including group air fares on longer trips. This estimate for travel is our best estimate of what we will require in fiscal year 1976. If the fare increases do not materialize, then we will adjust our travel expenditures accordingly.

BUDGET PROCEDURES

Mr. TALCOTT. May I make a general inquiry about budget procedures?

Here you are telling us you are anticipating some sort of an increase. It just happens that it is in air fares that we are talking about now. If you do anticipate and then it does not increase, we seldom see that adjustment. At least, it is never called to our attention. On the other hand, isn't it more appropriate as a budget procedure to just tell us what the costs are going to be now and then if you have an increase that is sudden and unexpected, to come to us for a supplemental? Isn't that a better procedure?

Mr. GROO. I will defer to Mr. Lilly, if I may, Mr. Talcott.

Mr. LILLY. There are several considerations that were in process at the time that this budget was developed, Mr. Talcott. As you recall, there was a bill passed by the Congress which contained a per diem increase, raising it up to $35 per day maximum. It took place during that time period; it was subsequently vetoed and is being acted upon again at this time.

Mr. TALCOTT. You did not act upon that prior to the veto? You did not act on the passage of the bill by the Congress before it was vetoed by the President?

Mr. LILLY. I do not recall the exact date when it was vetoed. We submitted our budget and started negotiations with OMB at the end

of September. It was all happening about the same time. In addition, at the time that the final budget decisions were being made, the Congress also placed a restriction, as an amendment to a supplemental bill, which reduced all Government-wide travel by 10 percent after the effective date of the law. This had the effect of a 5-percent reduction in fiscal year 1975. We were required to reduce our fiscal year 1975 travel budget by 5 percent.

It is my understanding, at this point, that a recent action of Congress would repeal that 10-percent reduction. Of the amount representing the increase, I believe $700,000 is attributable to rate increases already enacted and additional program-related travel.

TRAVEL LIMITATIONS

Mr. TALCOTT. I will have to admit that you people often have problems created by Congress.

The Senate created the travel limitation. We went along. Last December it was a 5-percent limitation. Just a couple of weeks ago in the supplemental bill, it was removed. It just does not make economic sense to me to vacillate like this.

I am surprised that you people would operate on a bill that is really not enacted yet.

Mr. LILLY. There is a standard procedure whereby we cannot anticipate the actions of Congress; we can only budget for those items that are scheduled. For example, wage agreements or union agreements that are in existence and are going to affect our requirements at a certain point in time, or an action that has already been passed by Congress.

Dr. FLETCHER. I would suggest that we hold the $700,000 in reserve.

PER DIEM ALLOWANCE

Mr. ROUSH. Dr. Fletcher, does the travel figure here include the per diem?

Dr. FLETCHER. Yes; it does.

Mr. ROUSH. Did you base your projection on the per diem as it now exists or as contemplated?

Mr. GROO. As it now exists.

AIR TARIFF STRUCTURE

Mr. BAUCUS. What is built into this increased air fare? Can you outline, A, B, and C—what the assumptions are?

Mr. MALAGA. Our best information in talking with the people who set the air traiff structure is that there is approximately a 12-percent rate increase, being considered. That is not on an annual basis. It is a cumulative value of what would happen if all the probable actions are taken based on petitions submitted to the Civil Aeronautics Board. We have taken the raises which have already been approved in April, October, and November of 1974 and included the impact in fiscal year 1976.

That is less than half of the total 8-percent increase we have talked about. The balance is the effect in 1976 of tariff increases based on fuel

cost increases. As I say, that comes up to about 12 percent. The effectivity of it is 8 percent in fiscal year 1976.

Mr. BAUCUS. Eight percent of the increase is due to increased fuel costs?

Mr. MALAGA. It is expected rate increases now being considered by the CAB based on increased fuel costs that have already taken place.

Mr. BAUCUS. As I understand, Dr. Fletcher said you generally do not anticipate these kinds of increases.

Dr. FLETCHER. It is unusual.

Mr. TALCOTT. We are talking about two factors here which complicate a budget officer's problems. One is the anticipated increase by the air carriers, which is pretty well known and a good business person contemplates these kinds of effects particularly if you go down to the agencies and ask what is going to happen. Then there is the other consideration that the Congress creates by imposing the 5-percent limitation in December and withdrawing it in January.

That is a factor I do not think you should take into consideration in your budget proposals because that is not the law yet.

I think it is prudent management to think about what the air fares are going to be, where the employees will go, and how often. I think it makes the budget officer's job inordinately complex with all the factors you have to consider.

TRAVEL LIMITATIONS

I am surprised you come as close as you do.

Mr. MALAGA. Travel is a special case because to spend one additional dollar beyond our budget estimate for travel would take an act of Congress. We can only spend what we have asked the Congress for in our budget estimates, so we have to be very careful about travel.

The second point is that in the last 5 years NASA has never overestimated the rate of inflation in any of the estimates. In every case, we have had a shortfall in terms of funding to take care of inflation in our program. I do not think that in effect we are going to have funds we can consider for reprograming even if the full rate increases do not take place, because with what is happening to us in support contracts and utilities, it is a constant struggle for us to meet our requirements within available R. & P.M. appropriations. It is always tight.

Mr. BAUCUS. Assume that the repeal of the 5 percent cutback is in effect. Are you going to use that $800,000 or not?

Mr. GROO. We have made no specific plans for increasing current travel estimates.

Mr. LILLY. The only source would be by taking funds from other R. & P.M. functions or from R. & D. and that would be very hard. NASA management would have to consider it an extremely critical requirement. Our funds are very tight.

As we stated, there are no plans for that at this point.

PERSONNEL AND RELATED COSTS

Mr. BAUCUS. Let's turn to page SUM 4.

Under personnel and related costs, it is indicated that the 1975 increases are partially offset by annualized savings from the reduction

of 300 positions in fiscal 1975. The question is what is the full year's savings realized for those 300 positions?

Mr. GROO. $425,000 in 1975. It is $5 million in 1976 for the 300 positions.

NASA PERMANENT CIVIL SERVICE EMPLOYMENT

Mr. BAUCUS. Let's turn to page SUM 10 while we are on the subject of employment.

Last year you told this committee that NASA was planning on reducing employment by 354 positions. The table there indicates that you made that reduction plus another 300 ordered by the President last September, making a total of 654. Did most of those reductions come from the Marshall Space Flight Center?

Mr. GROO. Mr. Chairman, 354 of those positions are reductions at the Marshall Space Flight Center through a reduction-in-force at Marshall planned in the fiscal year 1975 budget. Fifty positions were eliminated when the Plum Brook Station at the Lewis Research Center was placed in a standby mode. The remaining 300 positions are reductions based upon the President's direction of last September. The total is 704.

MSFC EMPLOYMENT REDUCTION

Mr. BAUCUS. Why so many at Marshall?

Mr. GROO. We have been in the process of reviewing the work of the Marshall Space Center over a period of years. We have recognized that we could meet the currently planned workload of the Marshall Space Flight Center with fewer people. Therefore, the reduction-in-force was planned in our fiscal year 1975 budget.

Dr. LOW. A good part of this reduction was because of the phaseout of the Skylab program. A large number of Marshall personnel were involved in Skylab, which was completed last year. Of course, this was planned in the fiscal year 1975 budget, as Mr. Groo indicated. But we are through with that now. The reduction anticipated at Marshall is essentially completed.

POST-ASTP EMPLOYMENT DROPS

Mr. BAUCUS. After the Apollo-Soyuz flight in July, we are wondering whether NASA employment will drop any further.

Mr. GROO. We anticipate a drop in support service personnel after ASTP, but not a drop in Civil Service.

Mr. BAUCUS. Is there any way to quantify that drop?

Mr. GROO. It is approximately 1,700 people. Some are stage contractors, the people who prepared the spacecraft and vehicle for launch; the rest are the base contractors who are involved in supporting the launch.

The decrease in the stage contractors is 846. There are 857 support contractor people, primarily located at Kennedy, Johnson and Marshall, who are involved in ASTP and will also be reduced.

NASA EMPLOYMENT PROJECTIONS

Mr. BAUCUS. When the Shuttle begins to come on line, what kind of an increase do you anticipate?

Mr. GROO. We anticipate some necessary buildup. Our runout estimates suggest building backup from 48,700 total in-house manpower in 1976 to 51,500 in 1979. That includes a buildup in support contractors of approximately 2,000 people.

Mr. BAUCUS. So the increase is how many?

Mr. GROO. About 2,000 support contractors and an increase of approximately 2,800 people in total, including stage contractors at KSC. No change in civil service.

Mr. BAUCUS. What do you mean by runout?

Mr. GROO. As the program builds up toward the point of the Shuttle's first manned orbital flight in 1979, we will begin to build up our activities, such as our launch support activities at the Kennedy Space Center; therefore, we will need more contractor people on board to assist in that launch.

Mr. BAUCUS. Generally, what is the definition of the term "runout"?

Mr. GROO. Runout means the resources required in future years for completion of an approved program.

Dr. LOW. Mr. Chairman, I would like to add one thought on the manpower for the Shuttle that Mr. Groo discussed. The buildup which he was discussing occurs during the test phase of the Shuttle, as it is moving toward initial operations. When the Shuttle is fully operational, that manpower will come down. It will not take that many people to operate the Shuttle in the operational phase.

NO CIVIL SERVICE INCREASE CURRENTLY ANTICIPATED

Mr. BAUCUS. Just so I am absolutely clear on this, did I understand you to say there will be no increase in NASA civil service employment?

Mr. GROO. Yes, sir. No civil service increase in employment over present levels is currently anticipated.

SUPPORT CONTRACTOR PERSONNEL

Mr. BAUCUS. What increases will there be?

Dr. FLETCHER. Mr. Chairman, we speak of support contractors as in-house personnel but they are employees of private companies that support the individual center operations. They are physically located at the center. When we speak of support personnel, we mean private contractor personnel who are located at a center but are not civil service personnel.

Mr. BAUCUS. As you describe the term "Total permanent positions" in the budget, that is just civil service, not the contractors?

Dr. FLETCHER. That is correct, Mr. Chairman.

R. & P.M. TRANSITION PERIOD REQUIREMENTS

Mr. BAUCUS. Let's turn back to page SUM 3.

I notice at the bottom of the page, that the transition request is $213,800,000. If that amount is annualized over four quarters it would represent a full-year level of $855.2 million.

The basic question is why is that transition period request so high?

Mr. GROO. The basic answer to that question is that the first quarter of the normal 12-month fiscal year is a quarter in which specific items require more new obligational authority than in other quarters.

The principal contributor to this higher amount is in terms of our various services, such as facilities services, technical services, and administrative support services, which are in many cases contracted for during that July–September time period to cover the entire ensuing year. That results in substantially higher obligations. For instance, facility services are 33.7 percent of the 1976 amount. Technical services are 30 percent and administrative support services are 30.7 percent. So it is principally those functions plus the impact of first-quarter travel. We have historically had heavier travel in the July–September quarter, and we had planned our travel obligations in that transition period based upon the history of travel costs during that time. As far as personnel is concerned, there are $7.3 million additional costs in personnel. There happens to be an extra half day in that quarter in terms of the average during fiscal year 1976. We will begin that quarter with the going salary rate at the end of fiscal 1976, which is somewhat higher than the average during 1976.

We have $1.2 million for ingrade increases and promotions. In that quarter, there is a regular Wage Board determination on certain of our wage-grade employees, particularly at the Lewis Research Center in Cleveland. Finally, during that quarter we pay workmen's compensation for the entire year. These requirements all add up to an amount that accounts for the difference between 25 percent of the fiscal year 1976 level and the budget request for the transition period.

EXAMPLES OF TRANSITION-PERIOD SUPPORT CONTRACTS

Mr. BAUCUS. Now starting at the very beginning, you mentioned that contracts begin at this period. Can you give us some examples?

Mr. GROO. Yes, sir. The difference in our contract costs in that quarter over 25 percent of the fiscal year 1976 budget request is $8.6 million.

Mr. BAUCUS. Can you give me some examples?

Mr. GROO. At the Kennedy Space Center, which accounts for half of the difference, there are five typical contracts, one with Boeing, which deals with base support services. Another is our janitorial services with the Expedient Services Corp., for which we will obligate 75 percent of the entire year's estimate during that quarter.

R. & P.M. PROCUREMENT PATTERN

Mr. ROUSH. Why do you pay 75 percent of the entire year's cost during that quarter? Do you pay for these a year in advance?

Mr. GROO. No; we only obligate funds. We have to cover the requirements.

Mr. ROUSH. This transition period is causing a great deal of difficulty, is it not?

Mr. GROO. Yes, sir, in that sense it is. It is our normal practice to obligate these funds during the July through September quarter.

Mr. ROUSH. But there will not be that outlay during that period of time. The outlay will be consistent with the other quarters.

Mr. GROO. That is correct, Mr. Roush. This is a funding obligation.

Mr. LILLY. As you recognize, the change in the fiscal year will ultimately require some adjustment in our procurement process, where

the Government for many years has been operating in renewal of contracts or award contracts at the beginning of the July 1–June 30 fiscal year.

Going back in history, I believe, taking the research and program management appropriation, what is actually obligated during that time period has been in a range of about 27 or 28 percent of the total year. In terms of payments out of the Treasury, it is essentially 25 percent, except for slight perturbations caused by summer employment programs. There are certain charges made retroactive on Government agencies, such as workmen's compensation which is billed in that time period. The Labor Department bills you a year after the fact. They are forecasting, and we get our bill and pay the full amount, usually in the July and August time period. Then we are not billed again until the following year.

It is certain that these historical patterns will have to be adjusted eventually to accommodate the change in the fiscal year. In the case of the R. & P.M. requirements for the 3-month transition period, they are 27 or 28 percent as opposed to a straight 25 percent of the fiscal year 1976 level.

NATURE OF TRANSITION PERIOD

Mr. ROUSH. On your obligating funds, you are going to have to move on faith, are you not, that the Congress is going to then appropriate to take care of your contracts?

Mr. LILLY. This is specified each year, as you know. We are accustomed to operating in the procedure of a continuing resolution during that period.

Our budget during this transition period was developed essentially on the same rules as a continuing resolution. We abide by those laws and stipulations that you put into the continuing resolution, which depend upon the status of your bills at that time.

Mr. ROUSH. Not being a fiscal expert, it is somewhat confusing to me. I will have to give it some thought. Thank you.

Mr. TALCOTT. Are you going to make your contracts for the new year on a 15-month basis instead of a 12-month basis? How are you going to adapt your contractual agreements with the fiscal policy of the Congress?

Mr. LILLY. We have not provided funds for continuing for a 15-month period. In other words, it was just for certain contracts that had to be renewed at that point for 12 months and they would be picked up at that time and included in fiscal 1977 when the timing changes. Our instructions were to develop the requirements to cover the efforts planned in the 3-month transition period.

Mr. TALCOTT. As a general observation about the transition period, we are finding most of the agencies are anticipating a larger amount that would appear to be annualized by that quarter. This is shocking to many of us because we thought the larger amounts were obligated in the quarter just before the end of the fiscal year. That is when the agencies try their darndest to spend as much as they have remaining. We thought the quarter after the new year would be way down. We are finding it is way up with almost every agency.

It is hard to picture what is really going on here. Am I wrong in my general observations?

ANTI-DEFICIENCY ACT PROVISIONS

Mr. LILLY. If you take our total appropriation in this interim time period, the 3-month transition period, I believe it amounts to about 27.2 or 27.3 percent of the total 1976 quarter. It totals about 27 percent of the anticipated ongoing program for fiscal year 1977. I would imagine other agencies are fairly close on that.

If I may give you a little background, without getting into too much detail, that is the procedure provided by OMB in carrying out the Anti-Deficiency Act of the Congress, which stipulates "Thou shalt not obligate liabilities in excess of what Congress has appropriated." The Act requires each agency to file with OMB their internal procedures that would prevent the incurring of a liability in excess of that proposed.

In doing this, most agencies have required that when the agency undertakes what in fiscal terms is called a commitment—in other words, a contract which only one party has signed, the Government has signed or the Government has not—that must be covered by obligational authority. I would assume that all agencies' procedures are essentially the same. NASA and OMB took that factor into consideration in approving the amounts that we are allowed to request. That is basically the reason for the difference between the straight 25 percent and the 2 percent difference.

BUDGET AUTHORITY AND OUTLAYS

Mr. TALCOTT. All through our hearings here I think it is important to note that we are talking about new obligational authority rather than spending. My reference was to the spending habits of the agencies. They spend a lot during the last quarter of the year but the obligation, which we are really talking about here, does not occur that way.

Mr. ROUSH. If they took into consideration all of their obligations—are they consistent in this?

It seems to me you could have a tremendous sum in there for the transitional period. What we are really concerned about in that transitional period, and maybe I am wrong, are the outlays.

Mr. TALCOTT. That might happen after the obligations are permitted.

Dr. FLETCHER. I think we did supply the outlay estimate for the transition period.

R. & P.M. PROCUREMENT PATTERN

Mr. TRAXLER. The question I have is why are so many contracts let at this time of the year?

Mr. GROO. I would venture the answer that it is a matter of practice; that it represented the beginning of a new fiscal year and was a reasonable time to contract for new obligations for the rest of that year.

Mr. LILLY. One reason in particular is that R. & P.M. is a 1-year appropriation, available for obligation only in that 1 year. Most times the contract is limited to a 12-month period, and therefore the renewal comes on the anniversary of the award. However, the Congress and this committee did give us authority a number of years ago to enter into contracts which exceed the year; in other words,

exceed the 12-month period in order to distribute the workload more evenly.

In most cases, that is the reason why you don't see a tremendous buildup. It allows an agency to spread its administrative workload in terms of negotiations and in terms of procurement and issuing of contracts and procedures of this nature. So we do have the legal authority to exceed the 12 months, and our contracts over the years have been spread out. However, there are specific ones that are renewed in that immediate first-quarter time period.

NASA APPROPRIATIONS STRUCTURE

Mr. BAUCUS. Is this normal procedure? Do other agencies experience this same process?

Mr. LILLY. Yes, sir. I would assume that it is probably more pronounced in some agencies that have all annual appropriations. In our case, we have three kinds of appropriations: R. & D., which is a no-year appropriation, available for obligation until expended; construction of facilities, which is a multiyear—3-year—appropriation; and research and program management, which is only available for 1 year. So there would be more of a buildup in R. & P.M. than in the others for these contracts.

I am not familiar with all the other agencies in terms of what their patterns are.

UTILITIES COSTS

Mr. BAUCUS. Is part of this transition period disproportionate increase due to anticipated utility costs?

Mr. GROO. Basically, it is a $2.9 million increase for inflation.

Mr. BAUCUS. Are you anticipating higher utility costs for that period?

Mr. LILLY. We are budgeting to meet the requirements as we currently know them.

OUTLAY PROCESS

Mr. TALCOTT. Our subcommittee has generally dealt with new obligational authority. Other subcommittees under the Appropriations Committee concern themselves more with the spending process. I think that under the new Budget Control Act that we are going to be dealing with, it is going to require us to get into not only the new obligational authority but the spending functions of your operation. Next year your presentation to us probably by the new law will be required to be different.

TRAVEL REQUIREMENTS

Mr. BAUCUS. You said one of the reasons is because of higher air travel costs. Why is that? Why is there more travel?

Mr. GROO. It has been our historical experience that we have a higher than 25 percent rate during that particular quarter.

During the last 3 years, the average rate has been 29.9 percent of the total travel during the course of the year. We have used that figure as a basis on which we have established our travel requirements.

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BASIS FOR TRANSITION PERIOD TRAVEL

Mr. BAUCUS. The question is why is it higher?

Dr. FLETCHER. I think I can give a partial answer to that question. There are a large number of scientists, and this is not a very large amount of travel funds, who have to attend symposia and other scientific sessions to keep current in their fields.

A great many of these are in the academic community. Summertime is a time when the academic community is able to attend. As a result, these scientific meetings are planned during the summertime. That is only part of it, but to some extent this holds for the rest of NASA. They tend to schedule symposia when the scientists are available, which is generally in the summertime. You will find that true in any of your other science appropriations, I would estimate, perhaps, to an even greater degree.

Mr. GROO. I cannot answer that beyond that but we will try to find it and supply it for the record.

[The information follows:]

1. Travel to meetings, technical and scientific symposia, et cetera, in the July–September quarter historically runs higher than at any other time during the year.

2. Special requirements during the transition period include—

Travel to support preparations for the Shuttle orbiter approach and landing tests at the Flight Research Center requires extended TDY for Kennedy Space Center and Johnson Spacecraft Center personnel;

Viking flight mission support requires extended TDY for Langley Research Center personnel at the Jet Propulsion Laboratory; and

At Wallops Flight Center, 12-month funding for the Shuttle-bus support is obligated in the first quarter.

JUSTIFICATION FOR TRANSITION PERIOD TRAVEL REQUIREMENTS

Mr. BAUCUS. For the record, would you compare the transition period with the prior quarter and give the different amounts for travel between the two quarters and also the increases due to contracts. Also, you said workmen's compensation was another reason. Just compare those two periods in terms of travel, increased contracts, and the basic reasons why you think the increases will be necessary.

Mr. GROO. We will do that, Mr. Chairman.

[The information follows:]

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND PROGRAM MANAGEMENT

[Dollar amounts in millions]

	25 percent, fiscal year 1976 budget	Transition period	Δ
Personnel and related costs	$149.4	$156.8	+7.4
Extra day			+2.2
Summer program			+.9
Career development			+1.8
Workmen's compensation			+2.0
Other benefits			+.3
Training			+.2
Travel	4.3	5.1	+.8
Initial operations requirements			+.8
Operation of installation	40.3	51.9	+11.6
Contractual funding requirements			+11.6
Total	194.0	213.8	+19.8

The transition budget was developed on two bases. First, it was developed to reflect a continuance of the level of operations at the fiscal year 1976 level; and second, it provides sufficient obligational authority to continue those obligation patterns which have historically occurred during the July–September quarter. Because of this, the transition budget does not reflect 25 percent of the fiscal year 1976 budget request, nor will the fiscal year 1977 budget request be as large as four times the transition budget.

Historically, obligations in the July–September quarter have been more than a straight 25 percent of the full fiscal year. For example, in personnel and related costs, we obligate in the July–September quarter the bill for workmen's compensation from the Department of Labor which must be paid in full at that time. Also, the cost of temporary employment peaks in July and August as a result of the summer employment program.

In addition, obligations for travel have in the past been higher in the July–September quarter than at any other time in the year. This is partly attributable to the many scientific meetings held during the summertime to enable university participants to attend. Historically, one-third of the total cost of these meetings is obligated in this quarter. Also, we are planning for the heavy travel requirements related to the operation of the Viking-Mars surface experiments and the Shuttle orbiter and landing tests at Edwards, Calif., in this quarter.

The transition period estimate for facility services, technical services, and administrative support is at the level which provides for the continuation of fiscal year 1976 operations and the obligation patterns normally experienced in July–September quarter. For example, we experienced a higher than average cost for utilities during the summer because of air-conditioning needs, and for contracts that are renewed at that time or are funded to the end of the contract year.

ANTICIPATED FISCAL YEAR 1977 R. & P.M. BUDGET REQUEST

Mr. BAUCUS. Do you know what NASA's request for R. & P.M. will be for fiscal 1977?

Mr. GROO. We anticipate it will be the same level as fiscal year 1976, plus whatever increases there may be in civil service salaries that would occur in between.

DEFINITION OF TRAVEL

Mr. BAUCUS. Turning to SUM 6 and 7, the basic question deals with the different kinds of travel. I wonder if you would very briefly explain those three different kinds?

Mr. GROO. Program travel is related to the activities which are taken part in by the various center people and people from the NASA headquarters engaged directly in the management oversight of the direct programs of NASA. In other words, that is the fundamental reason for being of NASA and the travel necessary from one center to another or to a contractor's plant for a review of programs underway.

The program travel is the majority of our travel total. Administrative travel relates to the visits by functional managers from headquarters to various centers and from center people coming into headquarters to deal with administrative management matters. It also includes such things as local travel, buses, taxis, et cetera.

Finally, meetings and technical seminar travel are those expenditures for our engineers and scientists to participate in various technical meetings to keep abreast of various technical fields. We regard this as a very necessary activity to keep our people up to date in the technical fields for which they are responsible.

Mr. BAUCUS. What if Dr. Fletcher were to give a speech somewhere?

Mr. GROO. That would be administrative travel.

Dr. FLETCHER. It could be a technical seminar but so far I have not attended any.

Mr. LILLY. Incidentally, if Dr. Fletcher goes to oversee the launch of a vehicle or to carry out any kind of review, technical or otherwise, it is administrative travel. We consider Dr. Fletcher administrative, regardless of his technical background.

GSA RENTAL CHARGES

Mr. BAUCUS. Last year you indicated that GSA space rental was about $6 million. The question is whether you complied with the law limiting payment to GSA at 90 percent of those costs.

Mr. GROO. Yes, sir, we did comply.

Mr. BAUCUS. What is GSA charging this year?

Mr. GROO. In fiscal year 1975, $4.7 million; in fiscal year 1976, $4.782 million.

Mr. BAUCUS. Are those amounts proper?

Mr. GROO. As I understand it, those are the rates approved by OMB.

EQUITY OF GSA RENTAL CHARGES

Mr. BAUCUS. Have you checked whether GSA's rentals are fair?

Dr. FLETCHER. We do not have any control over the GSA, but we do discuss them with GSA.

Mr. TALCOTT. Who fights GSA if you don't?

Dr. FLETCHER. We do, but on rents it is sometimes hard to win.

Mr. BAUCUS. Have you checked to see whether they are fair?

Mr. TALCOTT. We try to keep an eye on the GSA, but we need help. Have you checked comparable office space?

Mr. LILLY. Yes, Mr. Talcott, we do. As you might recall from our testimony last year in terms of what GSA had done, we did succeed in negotiating a reduction of about $500,000 with GSA before we ever came in with the request.

As a result of the further cut in the course of the appropriations, action last year, we began to notice deterioration of our services at headquarters. I believe Dr. Fletcher and Dr. Low appointed some special groups to follow through and call their attention to every case where a service was not being provided.

I am not saying that they are not extremely tight on funds, but we have tried to be sure that their services to us are maintained as closely to what they have been as we can.

In terms of the rental rates for the buildings we occupy here in Washington, we are paying slightly around $6 a square foot.

That was established for us. I believe that comparable space throughout the Washington area is in excess of that amount.

REVIEW OF GSA RENTAL CHARGES

Mr. TALCOTT. So there are two parts of GSA, the rental of the space and maintenance and upkeep that you pay for.

General CURTIN. GSA has recently set up a procedure that permits the review process which you are suggesting. They outline to us the

billing for the future year as they see it. They break down the space into various categories, and the bill is submitted to us. We review it and have the opportunity to comment back to them. They have only recently, however, set up a reclama procedure.

We are in the process of adjudicating one of those cases with them right now, affecting Goddard Space Flight Center, where we feel the rates are excessive. We are trying to sit down with GSA and review this.

We have a procedure for doing that type of review, and we do not accept their statement of charges on a flat basis.

Mr. TALCOTT. That seems fair on both sides. We have been critical of GSA but if they are doing something right, I would like to give them credit.

General CURTIN. I think, Mr. Talcott, that this procedure will arrive at what you are saying, an equitable payment.

Mr. TALCOTT. In terms of the deterioration of maintenance and upkeep, that is endemic in Washington, D.C.

Mr. LILLY. We would expect an adjustment, but we are trying to maintain essential services.

Mr. TALCOTT. I think it is a fair criticism of the maintenance work all around Washington, D.C.

Mr. BAUCUS. On that happy note, we will adjourn until 1:30.

AFTERNOON SESSION

TRANSITION PERIOD REQUIREMENTS

Mr. BAUCUS. The committee will come to order.

Let's go back to some of the transition period questions we were discussing earlier.

Turning to page RPM 1–5, the question is why does the quarterly rate for permanent positions increase in that transition period, even though you are projecting the same number of people?

Mr. GROO. The quarterly rates for full personnel related costs?

Mr. BAUCUS. No; for permanent positions.

Mr. GROO. That comes out very close to 25 percent. To the extent that there is any increase at all, it's a function of the increases during fiscal year 1976 that causes a higher average rate going into the transition period and the extra half day in the transition period.

EXPLANATION OF TRANSITION PERIOD REQUIREMENTS

Mr. BAUCUS. One general observation I have had in going through this budget, with respect to the transition period, is that it would have been much more helpful to me if there had been a little more explanation of the differences between the figures for the transition period compared with the prior year, 1976.

Dr. LOW. Mr. Chairman, if you wish, we could provide a paragraph or two for the record which tries to explain more concisely than we were able to do this morning where the differences come from.

Mr. BAUCUS. That would be great. Provide a more detailed breakdown than we have here.

[The information follows:]

The transition budget was developed on two bases. First, it was developed to reflect a continuance of the level of operations at the fiscal year 1976 level and, second, it provides sufficient obligational authority to continue those obligation patterns which have historically occurred during the July–September quarter. Because of this, the transition budget does not reflect 25 percent of the fiscal year 1976 budget request nor will the fiscal year 1977 budget request be as large as four times the transition budget.

Historically, obligations in the July–September quarter have been more than a straight 25 percent of the full fiscal year. For example, in personnel and related costs, we obligate in the July–September quarter the bill for workmen's compensation from the Department of Labor which must be paid in full at that time. Also, the cost of temporary employment peaks in July and August as a result of the summer employment program.

In addition, obligations for travel have in the past been higher in the July–September quarter than at any other time in the year. This is partly attributable to the many scientific meetings held during the summer time to enable university participants to attend. Historically, one-third of the total cost of these meetings is obligated in this quarter. Also, we are planning for the heavy travel requirements related to the operation of the Viking-Mars surface experiments and the Shuttle orbiter and landing tests at Edwards, Calif., in this quarter.

The transition period estimate for facility services, technical services, and administrative support is at the level which provides for the continuation of fiscal year 1976 operations and the obligation patterns normally experienced in July–September quarter. For example, we experience a higher than average cost for utilities during the summer because of air-conditioning needs, and for contracts that are renewed at that time or are funded to end of the contract year.

Mr. LILLY. As to the other part of your remark, Mr. Chairman, I sincerely hope we won't have another transition period.

Mr. BAUCUS. I am hopeful we won't either.

Mr. BOLAND. And I hope we don't have any more deferrals and rescissions.

JSC—ADMINISTRATIVE SUPPORT

Mr. TALCOTT. May I ask one question on the transition period? We talked about some things which I think you mentioned were legitimately different for this transition period to the new fiscal year. On these leased lines and long distance tolls, on page RPM 1–15, it appears to me that your fiscal year 1975 budget was one figure, $914,000, and then the 1976 request goes down to $865,000. Then the annualized transition period is up. If it was continuously up, I could understand that. But in most of these items, administrative printing, which shouldn't have too much of a change, supplies, materials, and equipment, and the others, are not the kinds of things you mentioned this morning where one would naturally expect the transition period to be different. Every one of these shows 1975 at one level, and 1976 down and the transition period annualized is up. That is quite a phenomenon.

Mr. GROO. The transition period is the quarter in which the requirement for new obligational authority is historically the heaviest.

Mr. TALCOTT. It's even more, on an annual basis, than it was in 1975 or 1976.

Mr. GROO. Perhaps I should clarify that.

Mr. TALCOTT. I understood what you said. How about the annualized figures for installation support on that same page under administrative support services, the annualized figure shows an increase of 109 percent.

Dr. Low. This means principally that installation support consists of a number of contractors who provide service functions and many of these contracts come due in the first part of the year. They are for the obligations that are incurred during that period.

Mr. Malaga. For example, we have a motion picture production contract in support of some of the programs which is obligated 100 percent in that first quarter. That is the normal practice. That is what we do every year in the first quarter. We have a painting contract which is obligated, again for the full year. We also have a warehousing contract which is obligated for 4 months instead of 3 months. Again, it is normal practice.

Mr. Talcott. I am satisfied. I was one of those who was rather suspicious. I thought maybe you budgeters just took a transition quarter like this and tried to take off with it. You have a pretty good explanation.

Mr. Malaga. In every single case, we have attempted to cover our normal obligation patterns, not spending patterns but obligation patterns. That is what we have done.

Mr. Talcott. Mr. Chairman, I think that with the explanation, I am satisfied about the transition.

Mr. Baucus. Thank you. Let's stay on page RPM 1–15, "Administrative Support." At the top of the page, the figures indicate that at Johnson Center you are able to save about $1¼ million from the original fiscal year 1975 budget estimate of $8.218 million. How did you manage to make the saving? Why can you not continue to hold that line in fiscal year 1976?

Mr. Groo. The decrease in fiscal year 1975 from the fiscal year 1975 budget estimate to the current fiscal year 1975 estimate is the result of the purchase of some leased equipment which we had previously on rental, which was bought late in fiscal year 1974 and which reduced the lease cost during fiscal year 1975. In addition, we took certain energy conservation measures which had a reduction of cost in energy. The third thing was a reduction of some 12 man-years of effort in the support contract related to administrative support. The full benefit of those would show then in the actual cost of fiscal year 1975.

As far as fiscal year 1976 is concerned, there is an increase because of a wage-price escalation of some 7½ percent, which affected our support service contracts that were in effect at Johnson Center. That essentially covers the additional costs.

Dr. Low. Mr. Chairman, it really says that no matter how much belt tightening we do, and we do it all the time, inflation is getting ahead of us.

SUPPORT CONTRACTOR REQUIREMENTS

Mr. Baucus. I am curious why there weren't similar increases in other centers. Where were the increases? Were they in blue-collar workers or what?

Mr. Groo. First of all, the support service contractors that service the centers represent engineers, technicians, and as you say, blue-collar

workers. They perform various jobs such as custodial services, support to our data processing operations, and operational support to our various test facilities and engineering laboratories. They really run the gamut of the kinds of services we can contract out.

We have had, not just in Johnson, but in general, an increase in the cost of those kinds of services simply because a major number of those people come under the Service Contract Act and have been able to succeed in getting increases in their basic wage rates. That has reflected itself in the cost of contracts, not only at the Johnson Space Center but basically throughout all of the centers. As to how much outside support, we have considerably more at Kennedy, Johnson, and Marshall than we do at some of the research centers. But basically, all centers have some effect of that.

HISTORY OF SUPPORT CONTRACTOR PATTERNS

Mr. LILLY. If I could give you a little bit of history. Traditionally, NASA grew out of the NACA. The NACA was the nucleus of NASA when it was created. Traditionally, NACA had done essentially all their work in the older centers—Lewis, Ames, Langley, et cetera—using civil servants. Starting in the 1960's when the decision on the manned lunar landing program was made, and we created the Apollo program, NASA built the Johnson Space Center and the Kennedy Space Center and took over certain Army laboratories, which became the Marshall Space Flight Center. A determination was made at an early point that the total employment program to do this was going to have a hump and then come down. We made a management decision that we would use our civil service positions to provide a nucleus of basic scientific, engineering, and technical expertise and depend on support contractors in these newer centers to a larger degree for necessary support functions that we could package and do as specific mission kind of work.

That approach has evolved into this type of pattern where we have had more support contractor effort at the newer centers—Johnson. Kennedy and Marshall—than at research centers such as Langley, Ames, or Lewis.

SUPPORT SERVICE INCREASES

Mr. BAUCUS. For the record, could you break out which ones have received which increases? Is that possible?

Mr. GROO. We will do our best.

Mr. LOW. For Johnson or for all the centers?

Mr. BAUCUS. Particularly Johnson.

[The information follows:]

The table shows the result of actual wage and fringe increases experienced since January 1974 for some sample collective bargaining settlements at the Johnson Space Center.

JSC—Support contract wage and fringe increases

	1st year increase, percent
Rigging and test	16
Custodial	8
Logistics	15

NATIONAL SPACE TECHNOLOGY LABORATORIES

Mr. BAUCUS. Let's turn to page RPM 4–1, the National Space Technology Laboratories. The curious thing here is the name change. Could you tell the committee why this facility's name has been changed?

Dr. FLETCHER. Mr. Chairman, we actually changed the role and status of what used to be called the Mississippi Test Facility. It was originally set up as a test facility for rocket engines and stages of the Saturn launch vehicles.

Dr. PETRONE. Two stages were tested here: the first and second stages for the Saturn V launch vehicle.

Dr. FLETCHER. As we phased out the Saturn work, we began to phase in multidisciplinary, multiagency work that had to do with research on environmental problems primarily. To do this, we brought in groups such as NOAA, EPA, and some State and local research organizations. It became an entirely different kind of operation.

At this point we decided, first, that it should no longer administratively report to the Marshall Space Flight Center, and second, that we ought to change the name to Laboratories to reflect its role more properly. The name we decided upon was the National Space Technology Laboratories.

TEST FIRINGS AT NSTL

Mr. BAUCUS. Thank you.

It's my understanding that the primary purpose of the NSTL is to static test large rocket engines in both liquid and solid boosters. Is that correct?

Mr. FLETCHER. That is a primary purpose. It was the only purpose years ago, but now it's only a part of the purpose. The other part, as I mentioned, is the space and environmental technology efforts.

Mr. BAUCUS. Can you tell me how many actual test firings were made in calendar year 1974?

Dr. PETRONE. In 1974 we made none, sir. We finished our last Apollo test, I believe, in 1970. We then put the static test facility into a "mothball" status. We started the conversion process to get ready for the Shuttle main engine testing. The first shuttle main engine integrated subsystem test firing will hopefully be in the month of May 1975. So from 1970 to May of this year, there will have been no hot firings. But we have been converting the test facilities to the Shuttle engine test requirements, and we will make a cluster firing. We will not fire the solid rockets at this facility.

Dr. LOW. The term "cluster" means firing all three main engines at the base of the Shuttle simultaneously.

Mr. BAUCUS. What will be the total number for 1975?

Dr. PETRONE. In May of this year, we will have our first single engine firing. Then there will be many. We could submit the number of tests for the record if you wish. We will be making a number of tests each day. We will reconfigure and put a flight configuration in the test stand. There will be many tests in 1975.

Mr. BAUCUS. Do you have any rough estimate now of how many?

Dr. FLETCHER. There will be on the order of 40, I believe.

Mr. YARDLEY. I think we are going to try to get 20 this year on that engine, but we hope to finish that 20 and have another going. This year there were to be about 40 engine firings.

[The information follows:]

We expect to conduct approximately 40 test firings of the Space Shuttle Main Engine (SSME) at the National Space Technology Laboratories (NSTL) during current year 1975.

ENGINE TESTING

Mr. BAUCUS. The justifications indicate that both the Space Shuttle main engine and the main propulsion test article will be tested. The question we had was whether any anticipated tests were scrubbed last year?

Dr. PETRONE. I am not aware of any.

Mr. YARDLEY. We eliminated one extra ISTB (integrated subsystems test bed) engine. But we haven't eliminated any testing. That was to be used for later testing, if needed.

Dr. LOW. Mr. Chairman, we build up our testing capability. We start with some prototype engines and finally test the actual flight engines. We use the term "ISTB" to describe some of the early prototype engines before we go to the flight type engine.

Mr. BOLAND. Why was that eliminated?

Mr. YARDLEY. The additional one was in the program in case something went wrong. We felt we could get by without that particular engine because the production engines will follow soon after.

Dr. LOW. It was to save some money.

NSTL EMPLOYMENT

Mr. BOLAND. May I ask what is the total number of permanent positions at the National Space Technology Laboratory? The number of 70 shown on page RPM 4–2 is the total number of NASA personnel there, is it?

Dr. PETRONE. Yes, sir, that is the permanent NASA civil service personnel who are part of NSTL.

Mr. BOLAND. In addition to the 70, how many are at that installation?

Mr. GROO. There are about 1,100 people there all told, including support contractors, NASA people, and tenants from other agencies.

I should point out that in addition to the 70 NASA permanent civil service personnel who are a part of NSTL, there are another 25 people from the Johnson Space Center who operate the Earth Resources Laboratory which is located at NSTL but which is a part of the Johnson Space Center. They are located there because there are a number of people from other agencies working on similar problems and they are working together on these efforts.

Mr. BOLAND. And they are NASA personnel from Johnson?

Mr. GROO. Yes, sir.

Mr. LILLY. As you recall, Mr. Boland, several years ago when we were phasing down the effort at the Mississippi Test Facility, as it was called then, an additional item was put into our fiscal year 1971 appropriations in which we were encouraged and directed to utilize these capabilities by taking steps to attract other user agencies to the site.

Since that time, we staff only for those kinds of indirect work necessary to carry out our work and we do the other work for other agencies on a reimbursable basis. We bring our own people for doing the direct test of engines in from Marshall, and from Houston for certain other aspects.

GODDARD SPACE FLIGHT CENTER

Mr. BAUCUS. Turning to the Goddard Space Center, it appears that the transition costs are pretty much in line with 1976. I am wondering why.

Mr. GROO. It has to do with some of their contracting practices. There is one major item of travel that is somewhat less because during the fiscal year 1976 period they will complete the outlook for space study. Thereafter, there is a slight increase in travel.

As far as the other areas are concecrned, such as facilities services, technical services and administrative support, it really has to do with their contracting practices compared with those pursued by some of the other Centers. So their rates of increase just happen to be a little less.

CENTER CONTRACTING PRACTICES

Mr. BAUCUS. Why are the contracting practices different here?

Mr. GROO. There are several reasons. Each Center has a certain amount of freedom to pursue the kinds of practices to get the support work done that it feels is appropriate in its area. Centers do not necessarily always contract the same things. It depends entirely upon what the necessities of that particular Center are. The mission at Goddard is different from the mission at Kennedy. Kennedy had a major emphasis on preparing for launch and launch support. Goddard is essentially a science Center and developer of unmanned spacecraft and so it results in a different set of needs to some degree, and therefore a different kind of support contract approach.

Dr. LOW. The differences are relatively small. As I recall it, Johnson Space Center was an average of 28 percent obligations in the first quarter, whereas at Goddard it was 26 percent. There are differences in the makeup and the mission of the centers.

HISTORICAL PATTERN OF R. & P.M. OBLIGATIONS

Dr. FLETCHER. Mr. Chairman, would it be helpful if we gave you some of that information from past years, in terms of the pattern at the Centers?

Mr. BAUCUS. That would be very helpful.

[The information follows:]

The transition budget is compared with previous first-quater experience considered most typical for each Center listed. Numbers are indicative of obligations related to all funds except those for personnel and travel:

Center	Percent of obligations from previous 1st quarter experience	Transition percent of fiscal year 1976
JSC	33.2	35.4
KSC	37.7	37.0
MSFC	29.7	29.6
GSFC	25.4	26.6
WFC	36.0	31.0
ARC	26.3	26.0
FRC	93.1	85.6
LaRC	25.3	25.9
LeRC	34.9	32.1
HQ	26.5	26.5

REVIEW OF CENTER REQUIREMENTS

Mr. BAUCUS. To what degree do you generally review the various practices among the Centers in order to satisfy yourselves that the differences are indeed merited?

Dr. FLETCHER. Because of this transition period, we are going to pay increased attention as to how they allocate various quarters. In the future we will take a little closer look at that.

Dr. LOW. Mr. Chairman, there is no complete answer to your question. There are some things that are extremely important to us to have uniform across the agency. Take, for example, executive positions. Mr. Groo and I review, approve and manage across the board every pay raise for every executive position no matter where that person is in NASA. We think that is what makes the agency run.

As to exactly what one set of contract services is at one Center as opposed to another Center is basically delegated to the field. We don't think it would be reasonable for us to control everything out of our "corporate office," if you will. In order to keep NASA Headquarters as small as possible, we delegate a number of functions, which we think are of not overriding importance, to the Centers. Other functions we do control very thoroughly. We balance these, depending on where we think it's important to manage from Headquarters and where we think it isn't.

R. & P.M. APPROPRIATIONS PROVISION

Mr. LILLY. If I may add one point, Mr. Chairman, I mentioned that our Research and Program Management appropriation is a "1-year" appropriation, which is available for only the work to be done in that 12-month period, with one exception. As approved by this committee, the language does include the following proviso: "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."

Part of the reason for that language is that most kinds of contractual efforts not only have to be negotiated and done at all the

centers, but they also have to come up through Headquarters to be reviewed in a legal sense by management and approved by the Administrator. In terms of the workload, it was administratively much more economical and much more efficient to spread these out. As a result, there is a different pattern over the year in order to keep the workload from rushing in at one time.

TRANSITION REQUIREMENTS

Mr. BAUCUS. Is it also true that one reason for the larger transition figures at some centers compared to others is due to the Space Shuttle work at those particular centers?

Mr. LILLY. You will find more changes in the R. & D. side for that kind of effort and the build-ups of particular curves. Most of the changes in the R. & P. M., which Mr. Groo has gone over, are the patterns that have been established over many years in terms of contract awards and renewals.

UTILITIES REQUIREMENTS

Mr. BAUCUS. Thank you.

On page RPM 5–11, there is a breakout of utility costs. It's apparent that Goddard's utility costs increased by about 66 percent in fiscal year 1975, which is reflected in corresponding increases in the current estimate above the budget estimate, and that the 1976 requests supposedly provides for the full year impact of that increase.

The question is whether the fiscal year 1976 utilities estimate at Goddard or any other center includes any hedge, anticipating further increases, or is this just annualized out?

Mr. GROO. It's an extrapolation of the rates that exist. It also includes a deliberate effort to control the amount of consumption. Goddard happens to be in a situation where in 1975 natural gas rates increased 102 percent. Although we reduced the utilization some 27 percent, we still have the kind of increase you see. That has been characteristic throughout the centers. We have the general impact of the higher rates, both in electricity, gas, and fuel oil. We have had that general occurrence throughout the agency.

Our approach is to try to control the amount of utilities consumed. We did in one year, from 1973 to 1974, reduced 23 percent across the Agency in terms of our consumption. There is a small reduction in total usage in the fiscal year 1976 budget.

WALLOPS FLIGHT CENTER

Mr. BAUCUS. Let's turn to the Wallops Flight Center. Is there anything you would like to tell the committee about any problems you might have or anything you anticipate? The committee has no special questions on this center.

Mr. GROO. Wallops is an excellent operation. They have a very fine man who has been running it for a number of years. He is Bob Krieger. He is very much of an expert in the field of sounding rockets and other efforts at Wallops. We are very happy with Wallops and its contribution. The center has very special expertise and capability unique in NASA and unique in this country in terms of its functions.

WALLOPS TRAVEL

Mr. LILLY. Mr. Chairman, with your permission, I would like to comment on the travel requirements for Wallops in fiscal year 1976 and in the transition period. The transition period shows $123,000 and an annual figure for fiscal year 1976 $251,000. This is shown on page RPM 6–3. That is a motor pool operation that is to be awarded and accounts for all except $8,000, I believe, in that time period.

AMES RESEARCH CENTER

Mr. BAUCUS. Now let's move to the Ames Research Center, page RPM 7–1. Last year you told the committee that Ames is working on three approaches for VTOL, over the wing, under the wing and through the wing. I am wondering now whether you can tell us which of the three appears to be the most promising.

Dr. LOVELACE. I think it may be a little premature for us to say at this point which appears to be the most promising. We are working still very closely with the Air Force in the development of their advanced medium STOL transport aircraft. We will participate in the flight test program, which will give us some good flight data.

We are also, in our own STOL programs at Ames, looking at the other concepts. It is premature at this point to say which of these would appear to be the most promising for civil applications. These assessments are still underway.

V/STOL PROGRESS

Mr. BAUCUS. Through the years I have heard a lot about V/STOL, just reading about it in the papers and you testified last year about V/STOL. I am wondering when we are going to be at the point when we are going to know whether it's commercially feasible. It seems to be something that has been going on for years and years. It reminds me a lot of nuclear power, something which has been in the means for years but somehow never quite there.

Dr. FLETCHER. Could I give you a layman's view, Mr. Chairman? My background is not in aviation, but I have been interested in the very same problem. There seem to be two kinds of problems. The STOL—short takeoff and landing—does require maybe 2,000 feet of runway and the VTOL—the vertical takeoff and landing—requires just a small pad, like a helicopter.

There are two basic problems. One is simply the cost per mile. We are working on ways to reduce that until it's comparable with the normal airplane. When you have a vertical takeoff, you do have to expend a certain amount of energy just in rising. It's not the most efficient way of going. I don't know what that is reduced to now in terms of fuel consumption per mile, but maybe it's 10 percent over the normal conventional takeoff and landing. That is one problem. I am not sure that is the main problem.

There is another problem, dealing with the airport facilities to take advantage of either the STOL or the VTOL, particularly the VTOL. You can take advantage of it in a number of different ways. One is by creating new, helicopter-type landing facilities, which is a little

awkward close into town, but that would be a way to do it for the big cities and urban areas. The other is to create new small airports out in the rural areas. That is a national problem. Everyone is afraid to take a chance on coming out with a new plane without knowing that people are going to take advantage of them with new airports and traffic control facilities. Both of those have to be developed at the same time.

Bringing those two together so that they coalesce at the appropriate time is not an easy task. Between ourselves and FAA, we see the STOL—the short takeoff and landing aircraft—as being the first version of this aircraft. We see that coming together perhaps in the 1980 period. Dr. Lovelace can probably add some comments.

Dr. LOVELACE. That is perfectly accurate, Dr. Fletcher. In terms of the traffic control problem, we have been working with the FAA, actually using a close-in landing strip at Ames. We are experimenting with the handling qualities, the controllability of STOL aircraft, with both current and future landing systems, such as the proposed new microwave landing system, so that we can understand the problems of how you integrate STOL aircraft with more conventional aircraft in an airport complex and really take full advantage of it. That is the other half of the problem that Dr. Fltecher referred to.

Mr. BAUCUS. As I understand it, you have two problems. One is the V/STOL developing the power.

Dr. FLETCHER. The aircraft itself, yes.

FEASIBILITY OF V/STOL AIRCRAFT

Mr. BAUCUS. The general question is, how much money is it going to take and how much time is it going to take to develop that? I am really leading ultimately to the question, can you make a square circle? Is it something you just can't do? Is it feasible or not?

Dr. FLETCHER. I don't think there is any question about technical feasibility, Mr. Chairman. We have both short takeoff and landing and vertical takeoff and landing planes available. The question is simply one of economy. How much does it cost to build such a plane and how much fuel does it use compared to conventional aircraft? I think we are getting answers that indicate that they are becoming fairly competitive from that point of view.

Mr. BAUCUS. Why does it take 10 years to develop a traffic pattern to integrate STOL aircraft in with conventional aircraft? That seems a little lengthy to me.

Dr. LOVELACE. First, let me just add one point to the prior question. That is that we are conducting studies, economic benefit analyses, of STOL operations to try to see where we are. Where is the technology of flight versus operations, the fuel efficiency of these kinds of systems. That will tell us how close we are to answering your question on whether or not it is an economically viable proposition.

The difficulty of mixing traffic is a problem because we should be concerned with safety. That causes us to want to understand very carefully what the mixing of different types of aircraft in a traffic control situation really does to the overall safety, efficiency, and utilization.

It may appear to be a relatively simple problem, but it's one that we are inclined to want to err on the conservative side for safety reasons.

Mr. BAUCUS. Is the FAA studying that second question?

Dr. LOVELACE. Yes, sir. In fact, they are the agency that will be responsible for the regulations controlling it. We are simply the agents to develop the parametric engineering data within which those decisions would be made.

CHARACTERISTICS OF STOL AIRCRAFT

Mr. BOLAND. When you are talking about a very short takeoff and landing, what size craft are you talking about? How short is the takeoff and the landing?

Dr. LOVELACE. At the most 2,000 to 3,000 feet.

Mr. BOLAND. They are doing that every day now.

Dr. FLETCHER. Not with jets.

Mr. BOLAND. No, not with jets but they are doing it with the DeHaviland Otter. The DeHaviland Otter is a short takeoff and landing aircraft.

Dr. LOVELACE. Yes, sir. In fact, we use a modified Buffalo research aircraft today, substantially modified, as an upper surface-blowing aircraft.

Mr. BOLAND. Your concern is with jet aircraft, I take it?

Dr. FLETCHER. Yes.

Mr. BOLAND. You don't have a problem with the propeller-driven aircraft. They don't have any problem in short takeoff.

Dr. LOW. There is no problem with the DeHaviland Otter in terms of its use. For example, I have taken it many times from the Houston Airport down to the Johnson Space Center, a 15-minute ride. We are looking at what can be done for the airplane that flies about 500 miles, fast enough to satisfy its customer and yet able to land close enough to the inner city and land in very suburban areas. That has generally turned out to be a jet aircraft with comfortable riding qualities, more comfortable than the DeHaviland Otter, yet economical enough to use. That is the kind ofairplane we are talking about.

Dr. LOVELACE. And carrying about 40 to 50 passengers.

Mr. BOLAND. The DeHaviland Otter carries 18 or 19?

Dr. LOVELACE. Yes. Those seem to be the general characteristics of an economically viable STOL aircraft.

Dr. LOW. The question is one of noise, economics, and ride quality. All of those have to be mixed in.

Mr. TALCOTT. And mixed with other forms or modes of transportation. The Marine Corps has a couple of operational squadrons of Harriers. Their big problem is how you mix them in with aircraft that are coming in at different landing speeds. There is a myriad of problems, if you want to try to start sorting them out. The cargo carrying capacity I would think would be something that is as important as the passenger capacity.

Dr. LOVELACE. Yes, sir. We are working in fact with the Marines in their Harrier operations to glean just that very data of their experience with a true VTOL, a vertical takeoff and landing system. That

data will become a part of this body of knowledge that we are trying to gather to allow for the decisions on STOL, VTOL, commercial operations.

Mr. BOLAND. I would think the VTOL would present enormous difficulties.

Dr. LOVELACE. It has, as Dr. Fletcher pointed out, a more distant capability than STOL. The vertical takeoff mode is very fuel inefficient, as you might imagine. We have not discounted this in our analyses and in our research to date. There still is an interest on the military side in vertical takeoff and landing.

U.S. CAPABILITY IN V/STOL TECHNOLOGY

Mr. BOLAND. There is always an interest there in almost anything.

Am I correct in saying that in this Nation the state of the art is as much advanced as it is anywhere in the world, like Britain or France?

Dr. LOVELACE. In aeronautics, in general?

Mr. BOLAND. No, in V/STOL.

Dr. FLETCHER. For jet aircraft I think it would be a fair statement; yes.

Dr. LOVELACE. Yes.

Mr. TALCOTT. Then why did we buy the Harrier?

Dr. LOVELACE. I think from a technology standpoint, Mr. Talcott, we built experimental aircraft in years past that would accomplish the vertical takeoff and landing. We never commercialized the version.

Mr. TALCOTT. I see the point the chairman was making. It was technology he was talking about. I was thinking of the commercially developed aircraft.

Dr. LOVELACE. We did not commercialize; that is correct.

AMES UTILITIES REQUIREMENTS

Mr. BAUCUS. On the top of page RPM 7–10, you show utility costs. The question is why is the Ames Research Center so little affected by increased utility costs compared to others?

Mr. GROO. The principal reason is because they had a large increase in their utilities during 1974. If you look at the change you will see that they jumped from $2.6 million in fiscal year 1974 to $3.9 million in fiscal year 1975. The Pacific Gas & Electric Co. has moved a little sooner than perhaps others. They had a sharp increase at that time.

Mr. BAUCUS. My recollection, in looking at the other budgets, is that most show increased costs significantly in fiscal year 1975.

Mr. GROO. They did. I have the numbers that show what happened at Ames between fiscal year 1974 and 1975, and they did have a quite sharp jump. Their rate went from essentially what amounts to 8½ mills per kilowatt hour to 1 cent per kilowatt hour. That had an enormous effect.

Mr. MALAGA. These rates are fixed now because of the rate increases that Mr. Groo. just mentioned which occurred in fiscal year 1975. They are fixed through fiscal year 1976. We went into quite a discussion with

the Bureau of Reclamation because of the tremendous increase that they were presenting in the last 12 to 18 months or so. That has been settled. The increase was cut down by one-half and now those rates will be effective through fiscal year 1976.

FLIGHT RESEARCH CENTER

Mr. BAUCUS. Thank you. Turn to the flight research center, on page RPM 8–1. This morning we briefly discussed a new hangar. If the hangar is built, and the Space Shuttle is in operation, and the hangar is enlarged to cover the aeronautical mission, will there be any interference or any problem with the two operations in the same hangar?

FRC HANGAR

Mr. GROO. We would not anticipate the two operations using the same hangar. While the Shuttle approach and landing testing is going on, we will use that hangar as a orbiter hanger. When this testing and early development flight testing is finished, we will then turn that hangar over for use in other testing.

PLANS FOR FRC HANGAR

Mr. BAUCUS. What happens if the hangar is used for the shelter? What you are telling me is that the Shuttle will not use this hangar after the testing is completed, is that correct?

Dr. LOW. The plans, Mr. Chairman, are to do the orbiter approach and landing testing at Edwards for a fairly short period of time, a couple of years, and then to use Edwards for the initial development landings of the Orbiter. After that, except for contingency or emergency landings, we will not use Edwards for the Shuttle. The FRC hangar will be available for other uses.

LANGLEY RESEARCH CENTER

Mr. BAUCUS. Thank you. Turn to the "Langley Research Center" on RPM 9–3. The current estimate is up by $3 million above the original 1975 estimate. The question is why?

Mr. GROO. One reason is that they had very sharp utility increases.

Mr. BAUCUS. Is it cost overruns of Viking?

Mr. MALAGA. Viking is an R. & D.-funded project. You are seeing here the effect of a pay raise under category 1, and the facilities services going from $5.8 million to $6.4 million. As Mr. Groo mentioned, utilities increase by $1 million because of the utility rate increase.

Mr. LULLY. There is one other point I might add, Mr. Chairman. In fiscal year 1976 there will be an increase in travel from Langley to the JPL control center during the time period of the landing on Mars.

LANGLEY PERMANENT POSITIONS

Mr. BAUCUS. On the same page, the justifications indicate a decline under lunar and planetary exploration. I am curious about the reason for that decrease.

Dr. PETRONE. That would be the effect of the Viking approaching completion.

Mr. BAUCUS. Although you show a decrease for that program, the total Center employment doesn't decrease. We are wondering where the employees are being transferred.

Mr. GROO. The principal transfer is under "Space applications," where they are the lead center in advanced applications flight experiment development, plus the space and nuclear research and technology efforts, which increase in 1976.

APPLICATIONS EFFORTS AT LANGLEY

Mr. BAUCUS. What are some of those applications?

Mr. GROO. Specifically, we have 36 people who will work on the Nimbus–G flight experiment package for pollution monitoring, among other activities. There will also be some increase of people in aeronautical research and technology in structures, and a number of other programs. So it's a reapplication of people who will be coming off the Viking program as it is phased down, and into other programs which are assigned to the Center.

Mr. BAUCUS. I have forgotten the chart you showed us 2 days ago showing the number of applications. Will there be more applications in 1976?

Dr. LOW. Mr. Chairman, on that chart we showed that we have a number of different kinds of application activities. For instance, Landsat, the Earth resources technology is one of the very important ones. Most of that work goes on, for example, at the Goddard Space Flight Center and the Johnson Center. Then we have weather satellites, pollution-monitoring satellites, communication satellites, and ocean dynamics satellites.

At Langley, the work in applications is devoted primarily to pollution-monitoring satellites and ocean dynamics satellites. We try to define different functions for different centers. The instruments for our Nimbus–G, which is one of the application satellites, a pollution-monitoring satellite, in part are being developed by the Langley Research Center. As Mr. Groo pointed out, some of the people coming off Viking are scheduled immediately to go to the development of the instruments for this Nimbus–G pollution-monitoring satellite.

BUILDUP IN APPLICATIONS WORK AT LANGLEY

Mr. BAUCUS. But will there be more applications work at Langley in fiscal year 1976?

Dr. LOW. It's a buildup going into the operational phase of the Nimbus–G satellite.

Dr. PETRONE. Nimbus was authorized in prior years. We are out on contract and getting into the instrumentation building phase.

Mr. GROO. I should add one point. There is a decrease in the number of personnel during fiscal year 1975, as a matter of fact, a decrease from 3,371 down to 3,332, which is a difference of some 39 people.

LEWIS RESEARCH CENTER

Mr. BAUCUS. On page RPM 10–1, there is the Lewis Research Center. I am curious about the 100-kilowatt wind generator. How much of the total power requirements at Lewis could this generate or handle?

Dr. PETRONE. This is being constructed as a program funded by the National Science Foundation. It is being taken over by ERDA. At this phase, we are conducting what we call our phase B definition efforts. We are defining a 100-kilowatt generator. We also have plans to define a 1,000-kilowatt generator. This is part of R. & D. We hope that it will help out in our search for new energy sources. We hope that it will have use in remote parts of our country. It will be used at Lewis as a research facility during the energy development phase.

Dr. LOW. It is not planned to apply it to generate electricity at Lewis. In fact, it will be built at a remote station from Lewis called the Plum Brook Station.

STATUS OF PLUM BROOK STATION

Mr. BAUCUS. What is the status of Plum Brook?

Mr. GROO. Plum Brook is in the status of being phased down to a standby mode. We have been in that process for approximately a year and a half. We have been on standby there, except for one major facility, since last summer. Although we attempted to find work for that facility, we could not find sufficient people who could use it. We still have work in process and will have until June of this year. But it is a facility so important to the country in terms of its capacity that we thought it should be held in a standby mode because it has a number of very major facilities that could be of use to the country. Therefore, we decided to put it on standby.

Mr. BAUCUS. Could some of it be used in cooperation with ERDA?

Mr. GROO. It's possible that it could be if the facilities that are there would be found to apply. As we work with ERDA, if there would be a program which would require the kinds of facilities there, it's possible it could be used.

Mr. BAUCUS. Is that being explored at all?

Mr. GROO. I don't think we have reached that point in our discussions.

Dr. FLETCHER. We did explore at some length the possibility of the Atomic Energy Commission using that facility. At the time, they felt that it was not suitable for their needs. The situation has now changed and we probably ought to try again with ERDA.

NASA CAPITAL INVESTMENT

Mr. BOLAND. You talk about the total capital investment and you say, "which includes *X* number of dollars of facilities held by contractors". Are these facilities owned by the contractors or are they owned by NASA?

Mr. LILLY. That account, Mr. Boland, is where there are contracts administered by that Center and the Government. It is Government-

owned equipment which the contractor is using. In other words, Government money is paying for it and it is owned by the Government. The accounting and responsibility are with that particular Center.

Mr. BOLAND. Thank you.

NASA HEADQUARTERS

Mr. BAUCUS. Turn to NASA headquarters on page RPM 11–4. It appears that indirect positions went up from the original fiscal year 1975 estimate of 895 to the current fiscal year 1975 estimate of 946, while all the decline came out of the program offices.

Mr. GROO. That is a function of assignment of work. Essentially we have two kinds of people at headquarters—those directly related to programs, which we call direct positions, and those who represent the overall agency management, which we call indirect positions. The overall headquarters has been reduced somewhat in size, and because of recent reorganizations, especially the establishment of the Office of Center Operations, we have redefined some positions to agencywide management.

Dr. FLETCHER. This shift does reflect our current organizational structure. We have always delegated quite a bit of authority to the centers, but as we contract, we want to be more integrated and to avoid any unnecessary duplication between centers.

Mr. Groo's Office of Center Operations is a fairly new one.

Mr. MALAGA. Mr. Chairman, I think that the 895 figure is on a different basis than the 946 figure. The 895 was the fiscal year 1975 budget estimate, while the 946 is the current estimate.

Mr. BAUCUS. What do you think it should be?

Mr. MALAGA. It should be at least 946 and perhaps somewhat more because of the reduction in the size of headquarters.

Mr. LILLY. Mr. Chairman, the primary reason for it is in terms of classification. As you know, the Agency was reorganized. Previously, the responsibility for institutional management of specific centers was assigned to the appropriate Program Associate Administrator. For instance, the Associate Administrator for Manned Space Flight had the overall institutional responsibility for the Kennedy, Johnson, and Marshall Space Flight Centers. Those particular people in the program offices were then classified as direct with the work under those centers.

When the Office of Center Operations was created, a number of people from those program offices were transferred into Mr. Groo's office. As a result, those people were reclassified as indirect, although the functions are essentially the same. That is the basic reason for the shift between the two. It is a reflection of the new organization.

JET PROPULSION LABORATORY

Mr. BAUCUS. Thank you.

Turn to "Jet Propulsion Laboratory" on page SA–3.

Again the justification shows travel jumping up by $500,000. Is the reason for that jump the same as for the other centers, or is there something different here?

Mr. GROO. To the best of my knowledge, that is exactly the same. We will have to give you the details on it.

Mr. BAUCUS. What specifically would be the reason here?

Mr. GROO. It would be principally travel for programs, but I will be glad to provide the specific reasons for the record.

REASONS FOR JPL TRAVEL INCREASE

Mr. BAUCUS. Could you provide that for the record?

[The information follows:]

Answer. The current travel estimate for 1975 is higher than the 1975 budget estimate due to the following:

Per diem and mileage allowances have been increased at JPL to levels which more closely approximate that of the Government. Per diem has increased 30 percent, from $10 per day to $13 per day plus lodging.

Mileage allowances have increased 20 percent, from 10 cents per mile to 12 cents per mile.

In addition, air fares and lodging costs have also risen.

Mr. BOLAND. I notice you say the increase in travel is as a result of higher airline fares, per diem and lodging costs. Why wouldn't this same reason be attributable to travel costs in other areas?

Mr. GROO. It essentially is, yes, sir.

SUPPORT SERVICE CONTRACTORS

Mr. BAUCUS. One general question. It is obvious that NASA's permanent civil service positions in fiscal year 1976 will remain at the present level. Historically, whenever agencies put on ceilings there is a tendency to transfer work over to contractor personnel. I am wondering if you have done any of this for 1976 at all?

Dr. FLETCHER. Mr. Chairman, we can provide that information for the record. Actually, we are going the other way on support contractor personnel. We are going to reduce by a significant number the people who are in what we call the support contracts. We can provide the exact number for the record, however.

Mr. BAUCUS. Please do that.

[The information follows:]

Support service contractors (man-years equivalents):

Fiscal year 1974	19,820
Fiscal year 1975	18,653
Fiscal year 1976	17,827

CHANGES IN FISCAL YEAR 1975 ESTIMATES

Mr. BAUCUS. At the very beginning on page SUM 3, the figures there show that after the congressional cut of $9.6 million and the adding back of $5.2 million transferred from R. & D., you had to absorb about $4.4 million. A very general question is: Where did you take that reduction?

Mr. GROO. I can tell you how that was done. The difference is basically in personnel and related costs, where we had a reduction of over $7 million and a reduction of $800,000 in travel related to congressional action last fall. On the other hand, we had increases in

utilities of about $4 million. All of these actions taken together result in a net reduction of $4.4 million.

The reduction in personnel costs was a function of an unexpectedly high number of retirements in June and December 1974. We had a number of people take advantage of the difference between the retirement benefits and continuing to work under frozen salaries. There was also a savings in severance pay and associated costs related to our being able to place more people who had been RIF'd into other Government jobs than we had anticipated. This was partially offset by an increase in the rate and the percentage of the Government's contribution for health benefits.

These actions account for the $7.1 million reduction in personnel and related costs in fiscal year 1975 from our original estimate.

EFFICIENCY IN GOVERNMENT

Mr. BAUCUS. My general impression is that NASA has done a fairly good job. You know the tremendous deficits we have facing us this next fiscal year and the next down the road.

We in the Congress, and people generally, are crying for more efficiency in Government. My question is, What areas do you foresee where you might be able to make some savings when you present your next budget request? I know it is tough right now but there has to be one, two, or three areas where perhaps there could be some savings. I wonder if you could enumerate what those one or two areas might be without ever implying that they should be made. I think it would be helpful to make the agency that much more efficient.

Mr. BOLAND. And whether or not the budget for NASA is going to be higher than $3.539 billion in fiscal year 1977.

Dr. FLETCHER. On improved efficiency and productivity we have and will continue to make moves in that direction. It is pretty hard to predict with any certainty the budget for fiscal year 1977 because of the uncertainties about inflation. We do not like to speculate about inflation.

Mr. BAUCUS. I realize it is hard to predict inflation but independent of that problem I think there still has to be one or two or three areas.

FISCAL YEAR 1977 BUDGET PROJECTION

Mr. LILLY. In response to Mr. Boland's question of whether or not the fiscal year 1977 budget will be higher than the fiscal year 1976 request, in the President's budget they carry a runout projection of $3,625 million. This excludes the impact of future inflation. If we continue the program that we currently have it will be more than $3.5 billion.

EFFICIENCY AND PRODUCTIVITY

Mr. TALCOTT. I will be surprised if you can pick out one, two, or three areas where you can be more efficient. As a matter of fact, if you do that, I will be very critical of you because I am assuming and have assumed for some time that you had the management capability of being efficient throughout your whole operation.

If you have let some areas get soft, I am going to have to assume that there are a lot of areas that are soft and I will be after the whole program.

Dr. FLETCHER. We are working continually to improve our efficiency. It is, of course, a continuing effort. Every year we come up with new ideas on how we can improve our productivity. For example, this year we came up with a way to live within a smaller travel budget by using tele-conferencing. This is a big improvement, which I would urge the rest of the Government to try. It is a way of communicating over long distances without transporting people. Approaches of that nature are innovative. We plan to continue to innovate in this area and will make some estimates as to where those innovations are in the fiscal year 1977 budget.

Mr. BOLAND. Mr. Baucus, thank you very much.

For my part, I have been impressed with the hearings that the committee conducts with NASA. We are grateful for the forthright answers you give to our questions. I know I express the sentiment of the committee as a whole when I congratulate NASA on the way it conducts its agency.

Mr. TALCOTT. Is there a member of the press here? We have open meetings, but nobody comes.

[There was no response from the audience.]

Mr. BOLAND. They used to come when we had the Apollo program and the astronauts.

Thank you, gentlemen, very much.

Mr. BAUCUS. I, too, want to thank you very much, mostly because I am so new and I want to thank you for the help and assistance you have provided.

Mr. BOLAND. The committee will adjourn until Tuesday, March 11, 1975.

LIST OF WITNESSES

	Page
Curtin, Gen. R. H	1
Fletcher, Dr. J. C	1
Gray, E. Z	1
Griffin, G. D	1
Groo, Elmer	1
Hinners, Dr. N. W	1
Hosenball, Neil	1
Jenkins, Dr. H. G	1
Lilly, W. E	1
Lovelace, Dr. A. M	1
Low, Dr. G. M	1
Mathews, C. W	1
Petrone, Dr. R. A	1
Schmitt, Dr. H. H	1
Shapley, W. H	1
Truszynski, G. M	1
Yardley, J. F	1

INDEX

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

A

Page

Aeronautics and space technology 45, 468
Aeronautics fuel savings 18
Takeoff and landing aircraft 51
Aeronautical research and technology base 469
Aviation safety research 471
Major focus of program 469
Noise reduction 471, 472
Propulsion system technology 470
Refan program 470, 472
Supersonic cruise aircraft research 473
Concorde flights 475
Tilt rotor research aircraft 476
Airport operating procedures, improvement in 51
Deferral of fiscal year 1975 funds 468
Fuel-conservative aircraft technologies 46
Role of NASA in aeronautics 49
Space and nuclear research and technology 477

B

Budget constraints 3, 13, 418
Budget for fiscal year 1975, changes in 878
Budget for fiscal year 1976:
Impact of additional $200 million 446, 447, 448
Reduction in 879
Summary of 12, 50, 96
Budget for fiscal year 1977 879

C

Construction of facilities 498–657
Aeronautical facilities 653
Budget requirements for 1977 637
Deep space antenna 638
Funds requested of OMB 638
Johnson Space Center, lunar sample curatorial facility 656
Language proposed 637
Level of program 637
Priorities 639
Progress on projects 639
Rehabilitation and modification of facilities 656
Space Shuttle facilities 638, 640
Ames modification of transonic wind tunnel 652
Construction of orbiter approach and landing test facilities 645
FRC hangar requirements 647, 648
Modifications for hypergolic checkout and refurbishment facilities 645
Modifications for solid rocket booster component manufacturing and assembly facilities 651
Modifications for solid rocket booster processing 644
Modifications to launch complex 39 642
Modifications to launch control center 643
NASA–DOD roles 647
Orbiter approach and landing facilities at Palmdale 647

Construction of facilities—Continued
Space Shuttle facilities—Continued
Page
Orbiter approach and landing test facilities at FRC and Palmdale 646
Orbiter processing facility 643
Orbiter reprocessing activities 643
Orbiter/747 carrier aircraft operations 650
Overlap in NASA and Air Force facilities 646
Reprograming modification pending 652
Shuttle/carrier aircraft mating facilities 651, 654
Contingency funds 402
Contractors, support service 878

E

Earth resources survey satellites 17
Economic benefits of programs 2
Employment generated by NASA 445
Employment, impact of additional funds on 446, 447, 448
Energy programs 52, 477
Collection of solar energy 482
Coordination with NSF and ERDA 479
Contribution to energy field 52
Geothermal energy 53
Hydrogen injection automobile engine 55, 56
Mine safety and coal extraction 53
Modular integrated utility system 54
Reimbursable energy efforts 478
Research and development cost-benefit ratios 54
Solar base on the Moon 482
Solar heating and cooling research development and demonstration 52, 477
Space-based solar system studies 480, 482
Environmental effects 482
Use of information developed 480
Waste disposal 54
Water purification by activated carbon from sewage sludge 55
Equal opportunity progress 13

F

Funding levels 60

H

High energy sources 20
Highlights of program 15

I

Importance of space exploration 19
Inflation, impact of 13, 60

L

Launches 15

M

Manned space flight 21
Apollo-Soyuz test project 21, 419, 486
Space flight operations 413
Spacelab 403, 404, 413, 416
Concept verification testing 413
European development of 403, 414, 415, 416
Purpose of 404
Space processing potential 404
Use of 414
Space shuttle 22, 61, 401
Benefits from 64
Carrier aircraft 411, 413
Contingency funds 402
Cost of 65, 438, 452

Manned space flight—Continued
Space shuttle—Continued
Page
Cost per flight 406
Department of Defense requirements 61, 63
Development cost 14
External tank 417
GAO staff study on 435, 452
Interim upper stage/space tug 65, 418, 440
Launch sites 63
Orbiter approach and landing tests 412
Prime contracts and subcontracts 406
Reporting system 439
Spacelab 403, 404
Stratospheric effects of 406

N

National Space Association 411
New programs 4

O

Objectives of 17
Opportunities and choices in space science 70

P

Programs, principal 13

R

Research and development 94
Research and program management 657–880
Administrative support 862
Support contractor requirements 863
Air fare increases 849
Air tariff structure 850
Ames Research Center 870
Budget increases, reasons for 848
Budget procedures 849
Efficiency and productivity 879
Flight Research Center 874
Goddard Space Flight Center 867
Jet Propulsion Laboratory 877
Langley Research Center 874
Language provision 868
Lewis Research Center 876
NASA headquarters 877
National Space Technology Laboratories 865
Obligations 867
Personnel and related costs 851
Employment projections 852
Permanent employment 852
Reduction in employment 852
Support contractor personnel 853
Plum Brook Station 876
Procurement pattern 854, 856
Rental charges 860
Transfer authority 848
Transition period budget 853, 855, 861, 869
Administrative support 862
Antideficiency Act provisions 856
Budget authority and outlays 856
Outlay process 857
Travel costs 857, 858
Utility costs 857
Travel limitations 850, 851, 859
V/STOL aircraft progress 870
Wallops Flight Center 869
Return on investment in space program 3, 69, 446

S

	Page
Solar heating and cooling	18
Soviet space program	421
Space applications program	33, 459
Applications technology satellite	36, 39, 459
Communications satellites	36
Coordination of frequency allocations	459
Landsat (ERTS)	41, 461
Access to data	463
Agricultural data, release of	463
Cost of	464
Crop measurement	41, 42
Data printouts	465
Data transmission, safeguards on	465
Management and users of	43
Mineral exploration, potential for	464
Nimbus-G	460
Pollution monitoring	460
Seasat-A	466
Weather satellite	34, 37
Space science	26
Atmospheric studies	27
Cost of space science projects	456
Lunar and planetary exploration program	453
Life on other planets, theoretical research on	454
Launch vehicle procurement	457
Pioneer Venus	457
Viking program	29, 67, 437, 453
Opportunities and choices in	70
Physics and astronomy programs	422
Astronomy, priorities of	434
Ballon program	424
Orbiting/Solar observatory	30
Skylab data analysis	424
Skylab solar observations	30
Suborbital program—sounding rocket discoveries	423
Telescope, large space	31, 424, 442
Advantages of	433
Benefits from	426
Cost of	427, 428, 432
Energy sources, probability of	426
International participation in	425, 429
Mirrors	442, 443, 456
Phase B studies	444
Potential for scientific discoveries	434
Soviet participation	425
Study contractors	445
Technology from planetary programs	28
Statement of the Administrator	4

T

Technology utilization	488
Airport baggage checkout	492
Budget for fiscal year 1976	489
Cardiac pacemaker	490
Congressional Office of Technology Assessment	490
Examples of technology utilizations	494
Firefighters' breathing apparatus	491
Flat wire cabling applications	491
Image enhancement technology	493
Industrial applications centers	489
Spinoffs from Apollo	491
Tracking and data acquisitions	484
Core tracking stations	486
Cost of tracking and data relay satellite system	486
Madagascar station	485, 487
Transition period budget	2, 15, 59, 60

○