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DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT—INDEPENDENT AGENCIES APPROPRIATIONS FOR 1977

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HEARINGS

BEFORE A

SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS HOUSE OF REPRESENTATIVES

NINETY-FOURTH CONGRESS

SECOND 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 FISCAL YEAR 1977

WEDNESDAY, FEBRUARY 18, 1976.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WITNESSES

DR. JAMES C. FLETCHER, ADMINISTRATOR
DR. GEORGE M. LOW, DEPUTY ADMINISTRATOR
WILLIAM E. LILLY, COMPTROLLER
ELMER S. GROO, ASSOCIATE ADMINISTRATOR FOR CENTER OPERATIONS
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DR. ALAN M. LOVELACE, ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY
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GEN. ROBERT H. CURTIN, DIRECTOR OF FACILITIES
RAYMOND A. KLINE, ASSISTANT ADMINISTRATOR FOR INSTITUTIONAL MANAGEMENT

Appropriation	1975	1976	Transition	1977	Change from 1976 to 1977
Research and development	$2,331,015,000	$2,677,380,000	$700,600,000	$2,758,925,000	+$81,545,000
Construction	140,155,000	82,130,000	10,750,000	124,020,000	+41,890,000
Research and program management	759,975,000	[1] 795,498,000	[1] 220,795,000	814,055,000	+18,557,000
Total	3,231,145,000	3,555,008,000	932,145,000	3,697,000,000	+141,992,000
Positions	24,316	24,316	24,316	23,816	−500

[1] Includes proposed supplementals of $19,986,000 for fiscal year 1976 and $7,117,000 for the transition period for increased pay costs.

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, with the Administrator, Dr. James Fletcher; the Deputy Administrator, Dr. George Low; and the Comptroller, Mr. Bill Lilly. You are accompanied by some of your staff, Dr. Fletcher. Would you identify them and indicate whether or not we have any new ones here?

Dr. FLETCHER. I believe you know Dr. Noel Hinners. I think we have no new ones.

Mr. BOLAND. Noel was here last year. I remember him.

Let us see. Mr. Elmer S. Groo is the Associate Administrator for Center Operations. Mr. John F. Yardley is the Associate Administrator for Space Flight. 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; Mr. R. D. Ginter, Acting Assistant Administrator for Energy Programs; and Dr. Joseph P. Allen, Assistant Administrator for Legislative Affairs.

Mr. ROUSH. Mr. Chairman, Dr. Allen happens to be from Indiana. He is also an astronaut who has not yet flown. But I want to say a good word for him. He comes from Indiana and was educated in Indiana. I am sure he makes a worthy contribution to this team.

Mr. BOLAND. Indiana University?

Dr. ALLEN. No, sir, DePauw University in Greencastle, Ind.

Dr. FLETCHER. And he is very good at congressional relations, I might add.

Mr. BOLAND. I suppose the appointment of Joe Allen indicates the perspicacity of NASA. It is nice to have someone from Indiana in charge of legislative affairs, particularly when we have someone from Indiana on the subcommittee. That, of course, played no part in the employment of Joe.

FISCAL YEAR 1977 BUDGET REQUEST

Again, we are delighted to have you here this morning, Dr. Fletcher. You are appearing before the subcommittee today to testify on the fiscal year 1977 budget request for NASA. You are asking Congress to appropriate a total of $3,697 million for NASA. That is an increase of $141,992,000 over fiscal year 1976. I guess there is no disagreement over the fact that $3.7 billion is a good deal of money, even though NASA was operating at around $5 billion back in fiscal year 1964 to fiscal year 1966. I think all of us recognize—and I am sure that NASA does, too—that there are many in this country who feel that even $3.7 billion is too much money. Others may consider it not enough.

POLL ON GOVERNMENT SPENDING

I noted with some interest—I am sure you noted it, too—an article in the paper last week which talked about a poll identifying those areas of Government expenditures where the public feels Congress is providing too much or too little money. As I recall, 55 percent of those polled felt that NASA was one agency that should be reduced. That is a fairly startling figure, 55 percent; and if that poll has any validity at all, it does illustrate, I think to some extent, the lack of general public support for what NASA is doing.

At the same time, this committee recognizes that people can easily forget that many of NASA's accomplishments have resulted in hundreds of technological spinoffs that make everyday life a little bit more rewarding, and perhaps a little easier. But at the same time, I think that kind of a poll should serve as a warning. I indicated last year, at the time we opened these hearings, that it is vitally important that every dollar appropriated to NASA should have some strong economic and technological justification. That is why this subcommittee, from time to time, makes an attempt to play the devil's advocate. But we do that for the purpose of developing information which can be useful to us when we take this bill to the floor.

Also, these hearings are read by people in the space industry and people outside the space industry. So, it is important that the budget request carry strong, thorough justifications for the amounts which are requested. As we have in the past, we will continue to review your justifications in depth, and I am sure that these hearings will be helpful both to NASA and to the subcommittee.

With that statement, Dr. Fletcher, we will be very glad to hear your comments and testimony.

Dr. Fletcher. Mr. Chairman, if you will permit me, I would like to comment on the poll. It may be true that on the order of 50 percent of the sample polled want to reduce NASA's budget. But we also saw some data the other day that indicated that most people in the country felt that the NASA's budget was comparable with HEW's. It is not. It turns out that HEW spends more in just 1½ weeks than the entire NASA appropriation for 1 year. It is partly a lack of information on the part of the public.

GENERAL STATEMENT

With your permission, Mr. Chairman, what I would like to do is submit my entire statement for the record, and just cover orally some of the more important parts of it. Then, Dr. Low will follow me, and present, using slides, the main highlights of the ongoing program and our fiscal year 1977 request.

Mr. Boland. Fine.

[The information follows:]

Mr. Chairman and Members of the Subcommittee:

We are happy to be here today to begin your hearings on NASA's FY 1977 budget estimates. Next to me at the table are Dr. George Low, Deputy Administrator, and Mr. William Lilly, the NASA Comptroller. Also, as indicated on the witness list provided, we have here the senior NASA officials in charge of each of our principal program areas to respond to your questions on their parts of the budget.

With your permission, Mr. Chairman, I will submit my entire statement for the record but will cover orally only some of the most important parts of it; Dr. Low will then cover informally, with a few slides, the highlights of our FY 1977 program.

As shown in the attached table, NASA's FY 1977 budget estimates total $3,697 million, compared to appropriations totalling $3,555 million for FY 1976 (including a pending supplemental amount for civil service pay raises of $20 million). The President's FY 1977 Budget decision also includes a projected total estimate for NASA of $3,700 million for FY 1978, in accordance with the requirements of the Congressional Budget Act of 1974. This estimate for FY 1978 is essentially identical with the total requested for FY 1977, but does not include allowances for inflation beyond FY 1977.

For FY 1977, we have an apparent increase over FY 1976 of $142 million, or 4%. However, this increase is less than the anticipated rate of wage and price increases due to inflation, so actually there will be, in overall terms, a reduction of about 6% in effort and employment on NASA work in FY 1977 compared to FY 1976. I should also point out that the total NASA FY 1977 budget estimates now before you are about $200 million below the comparable FY 1977 figures, adjusted for inflation, submitted to Congress last year in the President's FY 1976 Budget. Thus, you can see that NASA's budget planning

for FY 1977 has been sharply impacted by the constraints the President has placed on the total Federal budget for FY 1977. This means that we in NASA have had to reduce ongoing space and aeronautics activities yet another time and defer important work we had hoped to undertake in FY 1977.

As reflected in the President's budget, the principal deferrals that have been necessary include:

- First, a one-year delay in initiating production of the third Space Shuttle orbiter. This will not delay the initial development flights of the Space Shuttle, which are still scheduled to begin in 1979, but will increase the risk in meeting early flight requirements and will somewhat increase the total cost. Funds for initiating production of the third orbiter are included, without provision for inflation, in the FY 1978 estimates, mentioned above, that are included in the FY 1977 Budget.

- Second, we have had to postpone, for consideration in next year's budget, starting the development of the Space Telescope. As you know, this project has been under discussion and study for several years and NASA and the scientific community agree that it will be a unique major new extension of man's ability to see out into the universe and backward in time. At the present time we have five contractors conducting Phase B studies which will be completed in March of this year. All of the studies and all of the recommendations of our advisory groups show the Space Telescope to be technically feasible and of the very highest scientific priority.

  We have been very mindful of the Subcommittee's concerns that we make every effort to minimize the cost of this project. Much progress has been made on both of these fronts, but we believe we may not yet have exhausted all of the possibilities. During FY 1977, therefore, we plan to see what more can be done to reduce costs without adversely impacting the scientific objectives. We do not intend to extend the current contractor Phase B work in FY 1977, since these studies will be complete in themselves.

In response to the Subcommittee's special interest in this project, Dr. Noel Hinners, Associate Administrator for Space Science, is prepared to give you a short special presentation on it later in the hearing, if you wish.

- Third, we have had to defer - also for consideration next year - starting the next step in our systematic long-range plan for the exploration of the solar systems. This is planned to be an unmanned mission to send a spacecraft into orbit around Jupiter and to send a probe into its mysterious atmosphere (this mission is now referred to as "JOP" for "Jupiter-Orbiter-Probe"). Jupiter's special interest lies in the fact that it is the largest planet and that it is really a very special type of body - somewhere between an ordinary planet, like the earth, and a star, like the sun.

  I might mention at this point that even before the final FY 1977 budget constraints, we had decided that our budget could not accommodate another planetary project that had a special priority because if not started in FY 1977 a rare opportunity would be lost. This was the Mariner-Jupiter-Uranus or "MJU" project to take advantage of the unique opportunity in the late 1970's to send a Mariner spacecraft on a fast trajectory for man's first closeup look at the very distant planet Uranus -- 1,700,000,000 miles away. Dr. Low will explain how we will try to get some data on Uranus at this launch opportunity without the expense of a major new project.

- Finally, we have had to defer once again, for consideration next year, a start on the repowering to increase the effectiveness of the 40' x 80' subsonic wind tunnel at the Ames Research Center. This construction project, which is strongly supported jointly by NASA and the Department of Defense, was approved by Congress in the NASA FY 1976 Authorization Act.

Even though severely constrained, the FY 1977 NASA budget has positive features. It will permit us to proceed, on a restricted basis, with most of our ongoing space and aeronautics programs. In addition, in contrast to FY 1976, this year's budget fortunately does contain some limited provision for initiating "next step" activities which, of course, are essential for continued progress and productivity in the program. These include:

- The Solar Maximum Mission (SMM) - a scientific spacecraft to study sun spots, solar flares and other solar phenomena during a period of peak solar activity in 1979-1980. With SMM, scientists will be able to build on the breakthroughs in the study of the sun resulting from the Skylab and Orbiting Solar Observatory missions and specifically gain a more complete understanding of the mechanisms leading to the releases of vast amounts of solar energy -- which has profound effects on life, weather and climate here on earth. With this mission we also will be able to provide an accurate measurement of the solar constant.

- MAGSAT - an applications explorer satellite to map the Earth's magnetic variations and to provide information expected to be useful in the exploration for natural resources such as oil and minerals.

- Thematic Mapper - a new instrument which will increase dramatically our future capabilities for the observation and monitoring of earth resources from space.

- National Transonic Facility - a specialized aeronautical research facility to be built at the Langley Research Center. This is an urgently needed aeronautical research facility that has been studied and supported jointly by both NASA and DOD over the last several years. It will provide advanced capabilities to represent air-flow characteristics for aircraft operations near the speed of sound and will have wide applications as an R&D tool for development of future civilian and military aircraft essential for maintaining United States leadership in aeronautics.

Since Dr. Low's presentation will cover the highlights of these programs and most of the remaining material in my statement, and since my entire statement will be in the record, I will now, in the interest of time, skip to page 8 for a few concluding remarks.

SPACE SHUTTLE

Space Shuttle development is proceeding on schedule, still pointing to the objective of accomplishing the first manned orbital flight in 1979. This year's budget is tight, but we are holding our major development milestones. Rollout of the first Shuttle orbiter is planned for September of

this year, leading to approach and landing tests at the Hugh L. Dryden Flight Research Center beginning in 1977. Work on the second orbiter, the vehicle which will fly the first manned orbital mission in 1979, is also progressing.

In Shuttle related areas, I can report that: (1) Spacelab development in Europe is progressing well; (2) the Department of Defense is proceeding to develop the Interim Upper Stage (IUS) for use with the Shuttle in accordance with the agreed joint NASA/DOD plans for the overall Space Transportation System; and, (3) we are beginning to design and develop hardware for experiments in the areas of space science, earth-oriented applications, and space technology that will take full advantage of the unique capabilities provided by the reusable Shuttle and Spacelab. As previously mentioned, however, budget constraints have required us to defer by one year initiation of production of the third orbiter, which we had planned to start in FY 1977.

SPACE SCIENCE AND APPLICATIONS

With the FY 1977 budget, we will be moving ahead with the space science and applications projects approved in past years, as well as starting the "next step" projects mentioned above. In addition, the study, analysis, and evaluation of scientific and applications data obtained on previous space missions will continue.

In CY 1975, we successfully launched 19 spacecraft, including the two Viking spacecraft which are on course to Mars, the Apollo-Soyuz joint U.S.-Soviet mission, eight other NASA missions, and eight missions for commercial users and for other countries. We had two launch vehicle failures--one with a NASA mission (the Dual Air Density Explorer) and one with a commercial communications satellite (an Intelsat F-4). Since the start of the year we have had three additional successful launches of cooperative satellites--the second U.S.-West German Helios solar probe and the U.S.-Canadian Communications Technology Satellite -- and a successful launch of an improved type of commercial communications satellite, an Intelsat F-4A.

We are in a period when we are launching more flights sponsored and paid for by other users than by NASA. In CY 1976 we expect to have a total of 16 to 19 launches, depending on customer decisions. Only two of these are entirely NASA-funded missions. Two others are NASA cooperative missions with other countries. The remaining 12 to 15 will be entirely funded by commercial organizations, other Federal agencies, or other nations. In CY 1977 we expect a total of 18 to 23 launches. Of these, only six will be missions primarily funded by NASA -- the two Mariner missions to Jupiter and Saturn, the first High Energy Astronomical Observatory, LANDSAT-C, International Sun-Earth Explorer,and the International Ultraviolet Explorer. I should mention that even the NASA-funded missions will involve significant scientific and financial participation by European governments.

NASA's cooperative international projects in 1975 included the highly successful Apollo-Soyuz Test Project, the use of ATS-6 for instructional television transmission to 5,000 villages in India, and increasing international participation in the LANDSAT earth resources program. Agencies in 50 nations are now funding projects that will assist NASA in judging LANDSAT's usefulness. Scientists from many countries have reported significant practical achievements in regional planning, managing natural resources and other important areas.

AERONAUTICS

In aeronautics, we will continue to focus our efforts on developing the technology which will permit the U.S. to produce aircraft capable of approximately twice the energy efficiency of current transport aircraft. A primary purpose of this effort is to provide the advanced technology that is essential to ensure that U.S. manufacturers will be in a strong competitive position in the world-wide market for the next generations of civil transport aircraft. NASA's aircraft energy efficiency technology efforts will include engine component improvements, experimental research for advanced transport aircraft and engines, and development and testing of aircraft structures using composite materials to achieve significant weight reductions.

ENERGY

NASA's activities in energy research and technology have been directed primarily toward (1) the special energy requirements of spacecraft - which require long duration, high

reliability, lightweight systems that will function effectively throughout the solar system; (2) identifying and refining technology developed in the space program which has the potential for making major contributions to solution of energy problems on earth; and (3) supporting and carrying out on a reimbursable basis energy research and development programs for which ERDA and the Department of the Interior are responsible but which NASA is especially well qualified to carry out because of its experience and capabilities in aeronautics and space technology. These programs include specific energy applications such as photovoltaics (solar cells), solar heating and cooling, and electric power generation by wind power.

The FY 1977 budget contains no request for continued direct R&D funding to NASA for terrestrial energy research and development. We will, of course, continue to make NASA's expertise and capabilities in energy technology available to ERDA and other agencies on a reimbursable basis.

TECHNOLOGY UTILIZATION

In the Technology Utilization program we are continuing to focus on beneficial applications of the technologies developed in our aerospace research and development. We are making an orderly growth in our efforts to ensure that these transfers benefit industry, medicine and the public sector.

Currently, more than 3,000 companies are participating with our network of Industrial Application Centers, whose main role is to assist private industry in the acquisition and application of NASA technology. Recent examples include computer programs used for railroad car design, support structures for critical sections of the Alaskan pipeline, and the development of new products by small business companies based on technology made available from these Centers. In the public sector, specific assistance to medical researchers has led to new devices for the handicapped and for eye patients. Similarly the needs of the cities to cope with public safety are being addressed through programs based on NASA technology which have produced new gear for fire fighting and new approaches to the handling of hazardous materials. The annual report of the Technology Utilization Program has been published and can be provided for the Subcommittee's records if you wish.

INSTITUTIONAL MANAGEMENT

During the past year, we have completed a careful examination of institutional roles and missions and personnel requirements throughout NASA. On the basis of this examination, we have made a number of clarifications in the work assignment to our centers. We have also been able to help meet the need for holding down expenditures in FY 1977 by reductions in personnel at our centers. As will be brought out in Dr. Low's remarks and subsequent hearings, we are planning a reduction of 500 civil service employees during FY 1977 as well as appropriate associated reduction in center support contractor effort.

EMPLOYMENT IMPLICATIONS

One aspect of the NASA program that was of special concern to the Subcommittee last year was the impact of the NASA program on employment, and on the economy as a whole. I have already mentioned that in constant dollars, the NASA budget will be down by about 6% from FY 1976. This will translate inexorably into a reduction of 10,000 in direct employment on NASA work by the end of FY 1977. This will include the reduction of 500 in civil service employment at NASA centers, but the greatest impact will be at industial contractor plants throughout the country. As a rule of thumb, we estimate that every $100,000,000 of NASA expenditures translates into about 4,000 direct jobs, and into a total employment impact of 10,000 jobs, using a multiplier factor of 2.5.

As for the broader economic impact of NASA expenditures, let me remind you of the studies we discussed with you last year, which confirmed that from an employment and economic standpoint, NASA-type expenditures in high technology have the advantages of being less inflationary in the short run and much more beneficial to the economy as a whole in the long run. This effect results from the fact that expenditures like NASA's on advanced technology have the economic effect of increasing productivity which, in turn, improves the performance of the economy as a whole.

Much of the current discussions of the actions to restore the Nation's economic health has failed to recognize the central importance of productivity. The plain facts are that

(1) there is no way in the long run that our economy can grow, with unemployment reduced and inflation held in check, except by increasing productivity, and (2) increases in productivity depend on the development and application of advanced technology. NASA expenditures--which are predominantly for advanced technology development and which are coupled with an effective Technology Utilization program--are therefore a significant constructive force in the right direction to support the long-term health of the economy. This special value of NASA expenditures is not possessed by most fiscal alternatives, and should, I believe, receive careful consideration in the review of our budget. In this connection, the Subcommittee may be interested in a paper recently prepared by our staff economist which addresses some of these problems and updates some of the study results we reported last year.

CONCLUSION

In summary, I believe that it is fair to say that the FY 1977 budget will permit NASA to move ahead: in space, toward an era of broad participation in the scientific exploration and practical applications; and, in aeronautics, toward aircraft of greatly improved efficiency and performance. The FY 1977 budget is certainly not all that we would have liked it to be, but it does provide for measured progress toward the Nation's objectives in space and aeronautics. Although this is to be one more year of holding the line, I believe that we will be able to continue to achieve significant accomplishments--and we remain fully committed to that goal.

Let me add one final point: I take great pride in NASA's own productivity and accomplishments in the face of continuing decreases in constant budget dollars. Nevertheless, we must not forget that an adequate continuing investment in the future--namely, in research and advanced technology--is the key to increasing national productivity, efficiency, and well being. Continual erosion of NASA's research and technology efforts, either directly by underfunding and repeated "squeezes" or indirectly by inflation, is bound to undercut the viability of the entire program, foreclose important opportunities for the Nation's future, and reduce to a trickle the flow of new advanced technology so vital for our economy. I trust that this will not be permitted to occur and that NASA's programs in aeronautics and space will in the future receive the full support, without further erosion, that they clearly deserve on their merits.

Mr. Chairman, this concludes my prepared statement. Unless you wish to ask questions of me at this point, Dr. Low will proceed with his presentation.

Attachment: Summary Table

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1977 BUDGET ESTIMATES
(Thousands of Dollars)

	Fiscal Year 1975 Budget Plan	Fiscal Year 1976 Budget Plan	Transition Quarter Budget Plan	Fiscal Year 1977 Appropriations Requested
Research and Development:				
SPACE FLIGHT	1,235,800	1,560,500	406,500	1,644,700
Space shuttle	797,500	1,206,000	321,000	1,288,100
Space flight operations	298,800	188,600	48,400	205,200
Expendable launch vehicles	139,500	165,900	37,100	151,400
SPACE SCIENCE	417,315	434,200	116,400	379,025
Physics and astronomy	136,315	159,300	43,500	165,800
Lunar and planetary exploration	261,200	254,100	67,700	191,100
Life sciences	19,800	20,800	5,200	22,125
APPLICATIONS	174,748	178,230	47,700	198,200
Space applications	174,748	178,230	47,700	198,200
AERONAUTICS AND SPACE TECHNOLOGY	237,765	250,250	63,100	271,100
Aeronautical research and technology	166,400	175,350	43,800	189,100
Space research and technology	71,365	74,900	19,300	82,000
ENERGY TECHNOLOGY APPLICATIONS	4,435	5,900	1,500	---
TRACKING AND DATA ACQUISITION	248,000	240,800	63,400	258,000
TECHNOLOGY UTILIZATION	5,500	7,500	2,000	7,900
Total, Research and Development	2,323,563	2,677,380	700,600	2,758,925
Construction of Facilities	142,655	82,130	10,750	124,020
Research and Program Management	764,704	795,498*	220,795*	814,055
TOTAL, BUDGET PLANS	3,230,922	3,555,008*	932,145*	3,697,000
TOTAL APPROPRIATIONS	3,231,145	3,555,008*	932,145*	3,697,000

*Includes pending supplemental to cover increased civil service salary rates effective October 1975 (FY 1976 $19,986,000; transition quarter $7,117,000).

BUDGET CONSTRAINTS

Dr. FLETCHER. Mr. Chairman, as you pointed out, we have an apparent increase in fiscal year 1977 over fiscal year 1976 of $142 million, which is a 4-percent increase. Of course, remembering this is a 15-month period, including the 3-month transition quarter, if you take into consideration the inflation being experienced in the aerospace and construction fields, that is about a 6-percent reduction in actual dollars from fiscal year 1976. It is approximately 6 percent below what was projected for fiscal year 1977, adjusted for inflation, in the President's fiscal year 1976 budget. So we actually had to cut about $200 million from our projected fiscal year 1977 estimate, and this means that there will be a 6-percent reduction in NASA's fiscal year 1977 efforts compared woth fiscal year 1976.

I will go into the major efforts that were deferred. These deferrals reflect the President's severe constraints on the entire Federal budget, and NASA, of course, took its share of that large cut. It does mean that we have to, once again, defer what we think is important work that we had hoped to accomplish in fiscal year 1977.

PRINCIPAL DEFERRALS

The principal deferrals that we experienced are as follows: First, we had a 1-year delay in starting the production of the third Space Shuttle orbiter. This is the first production orbiter. This deferral will result in increased total Shuttle program costs, and for several years, we will have just two orbiters. Of course, we can meet our early missions with those two orbiters, unless something happens to one or the other of those orbiters.

The second deferral—and this caused a great deal of consternation among the scientific community—was the Space Telescope. We have discussed this subject at some length with this committee. We have had five contractors conducting what we call phase B studies. These studies will be completed in March of this year. We still regard the Space Telescope as a very-high-priority program, but because of fiscal constraints we had to defer its initiation for consideration in the fiscal year 1978 budget process.

During this interim period, we plan to see what more can be done to reduce the cost of the Space Telescope without adversely affecting the scientific objectives. We have one consideration, which we have not yet resolved; that is, how the contractor teams will be held together while we defer initiation by 1 year. At the request of the authorization committees, we are looking at procurement methods which would reduce the burden on the industry in holding these teams together, but at the same time protect the Government's interests. We are examining the implications very carefully.

We are well aware of the committee's special interest in the Space Telescope, and Dr. Noel Hinners is here to present any aspect of it that you like. He is prepared to make a short statement, if you so desire, later.

The third item we had to defer was on automated spacecraft planned to study the mysterious atmosphere of the giant planet Jupiter. The spacecraft would go into orbit around Jupiter and the probe would penetrate the planet's atmosphere. This mission is called a Jupiter-

Orbiter-Probe. This is a high priority in continuing our systematic exploration of the solar system.

Prior to the final fiscal year 1977 budget contraints, we, ourselves decided that our budget could not accommodate the Mariner-Jupiter-Uranus (MJU) project, which would have had to be started in fiscal year 1977 to take advantage of a rare opportunity—one that occurs only about every 14 years—to send a Mariner spacecraft on a fast trajectory for a first closeup look at Uranus, which is about 1.7 billion miles away. However, we are hoping to come up with another way to obtain scientific data on Uranus, and Dr. Low will explain how we hope to do that.

Another activity that we deferred, once again, was the initiation of repowering of the 40-by-80-foot subsonic wind tunnel. Now, we discussed that at some length last year. This would be a much-needed modernization of the 40-by-80-foot subsonic wind tunnel at the Ames Research Center, to be initiated in two phases. One is to increase the power; the other is to increase the working section, which is now 40 by 80 feet, and would be increased to accommodate larger aircraft. We had to defer that effort for reconsideration in the fiscal year 1978 budget process.

PRINCIPAL PROGRAMS

Now, it seems pretty bleak when we talk about the deferrals, because we were very enthusiastic about these activities. But there are some positive features in our fiscal year 1977 budget, and some progress in the way of next step initiatives, which particularly pleases us since, as you recall, NASA had initiated no new program starts in fiscal year 1976.

First, we do plan to start in fiscal year 1977 the Solar Maximum Mission, which is a satellite to study the Sun during the next period of peak solar activity in 1979 and 1980. As you know, sunspots have a cycle of about 11 years, and the Sun will be very active during that period. We have gained important scientific breakthroughs from the Skylab and Orbiting Solar Observatory missions. The Solar Maximum Mission will build on this information and help us to gain more complete understanding of the powerful energy sources of our Sun. Dr. Low will have more to say about this later.

Also included in the fiscal year 1977 budget request is initiation of MAGSAT, an applications Explorer satellite, to map the magnetic variations of the Earth's field. This is helpful not only from a scientific point of view, but also helpful in terms of its potential in exploration for minerals and possibly for petroleum.

We also propose to start an instrument development called the thematic mapper, which someday will dramatically increase our capabilities for monitoring the Earth's resources from space.

In addition, the fiscal year 1977 budget request includes funding to start construction of the National Transonic Facility. As we discussed with you last year, the National Transonic Facility will be a specialized aeronautical facility to be built at the Langley Research Center. It is a long-overdue start. This facility will provide advanced capabilities for measuring airflow characteristics of aircraft operating near the speed of sound and will contribute to the goal of maintaining

U.S. leadership in aeronautics. It was studied and supported by NASA and DOD.

KEY ECONOMIC CONSIDERATIONS

Now, since Dr. Low's presentation will cover the highlights, I would like, with your permission, Mr. Chairman, to discuss several key considerations which I think merit the attention of the committee. The first has to do with economic and employment implications. As I mentioned before, NASA's fiscal year 1977 budget, in constant dollars, will be down by about 6 percent from fiscal year 1976. This has a direct effect on employment on NASA programs in terms of 10,000 people that will lose direct employment as a result of this cut; and that includes 500 civil servants at the various NASA centers.

ECONOMIC IMPACT

As a rule of thumb, we estimate that every $100 million cut in NASA's budget translates into a loss of about 4,000 direct jobs and into a total employment impact of about 10,000 jobs, considering a multiplier factor of 2.5. Since our fiscal year 1977 budget request is approximately $200 million below last year's projection, adjusted for inflation, this means that there will be about 8,000 fewer direct jobs on NASA programs and a total employment impact of up to 20,000 fewer jobs.

BENEFITS FROM NASA PROGRAMS

In terms of the broader economic impact of NASA's programs, which was also a matter of interest to the committee last year, there is a strong relationship of high technology expenditures, such as we have in NASA, on productivity and efficiency of the overall economy. It is clear that NASA expenditures in high technology areas have the positive effect of creating jobs immediately, like many other proposals. But NASA expenditures are less inflationary than most other proposals in the short run, because of the underemployment as well as the underutilization of existing industrial capacity in the aerospace industry.

More importantly, in the long run, NASA expenditures have significant beneficial effects in increasing productivity, which enhances the performance of the overall economy. As a matter of fact, much of the discussions on ways to restore the Nation's economic health leaves out this idea of productivity. They simply assume that by doing certain things, we can cure both inflation and unemployment. The facts are that in the long run, the only way to help solve both these problems is to increase productivity, and this increased productivity depends on development and application of advanced technology.

We have spent a great deal of time looking at this problem, as many economists have. And in our view, we feel that there is no way, in the long run, that our economy can grow while still keeping unemployment down and holding inflation in check without major expenditures in advanced technology. This is the way our country has grown to the place where it is now, and we think that is the way it will continue to grow in the future.

Therefore, the special feature of NASA expenditures must certainly be recognized in any consideration of budget cuts or budget increases. We have prepared a paper which I think Members of Congress would find very readable and which summarizes some of these aspects. I would be glad to submit this paper for the record, Mr. Chairman, or submit it for your own use, if you are so inclined.

Mr. BOLAND. Why do you not submit it for the record?

[The information follows:]

2/9/76

ABSTRACT

SHORT AND LONG TERM IMPACTS OF NASA
R&D SPENDING ON THE ECONOMY

There has been a dramatic decline in productivity growth in the United States starting in the late 1960's and continuing to the present. From 1947 to 1966, output/man-hour in the private nonfarm sector of the economy increased at an annual rate of 2.9 percent per year; since then the figure has declined to approximately 1 percent per year. The consequences: Per capita income in the U.S. has moved from first to fifth in the ranking among major nations, as the rate of technological progress in the U.S. declines below all of our major competitors. Our current inflation has been intensified by our inability to offset rapidly rising wages rates against productivity gains. Although partially the consequence of our current recession, the drop in productivity growth appears primarily to be a long term problem. It appears to be a problem that will not, in general, be solved by managing the level of aggregate demand. Moreover, it appears to be a problem that is directly related to the ability of fiscal policy to break the wage-price inflationary spiral.

The argument presented in this report is that for fiscal policy to effectively contribute to overcoming the long-run productivity growth problem, it must differentiate among Federal expenditures on the basis of their productivity impacts. Evidence of several types is presented showing that NASA R&D expenditures, after a lag, generate spinoffs to the private sector in the form of new products and production techniques, which in the aggregate have a substantial impact on technological progress and hence productivity growth. Through incorporation of these NASA R&D productivity impacts into the Chase Econometric Model of the U.S. economy, results are presented showing significant long-run impacts of NASA R&D expenditures on increasing real income, increasing employment, and reducing inflation.

Although the major emphasis of this report is on long-run productivity effects, evidence is also presented showing that NASA expenditures are relatively efficient in increasing short-run employment without generating inflationary problems.

SHORT AND LONG TERM IMPACTS OF NASA R&D SPENDING ON THE ECONOMY

Since the Keynsian revolution of the 30's, the dominant thrust in fiscal and monetary policy has been the achievement of full employment economic stabilization through managing the level of aggregate demand by tax and/or Federal government spending policies. One only need consider the present measures used to judge the correctness of fiscal policy--measures, such as budget expenditure ceilings, deficit levels, monetary growth rates, etc.,--to see the pervasiveness of the Keynisian philosophy in present thinking. Certainly, no one would deny that aggregate demand management is a crucial element of fiscal and monetary policy. Yet the evidence of the last couple of years clearly suggests that the problem and its solutions are much more complex than simply eliminating imbalances between aggregate expenditures and total capacity. And not surprisingly, economists themselves are critically scrutinizing the efficacy of Keynsian demand management notions.

In his 1974 American Economic Association Presidential speech, Former Council of Economic Advisors Chairman, Walter Heller, summarized much of the recent thinking on the causes of our present inflation problems. "They (economists) differentiate among (1) excess demand, which had spent most of its force by early in 1974, (2) the price-wage spiral, which bagan to turn more rapidly in 1974, and (3) external-shock or special sector inflation, in particular, the commodity-price surges that permeate the present inflation and account for its special character and ferocity. The first responds rather readily to monetary-fiscal pressure, the second responds more reluctantly, and the third is highly resistant to the demand-management measures of any given country. For the second and especially the third types, therefore, high costs in unemployment and foregone output have to be incurred for small gains in curbing inflation..." (American Economic Review, March 1975, p. 21).

In addition to the fact that simple demand management no longer appears to be the powerful policy tool it has been in the past, another trend is emerging that worries economists. This is the trend in the growth of productivity. Of all the developed countries, the United States has had the lowest growth in productivity during the decade of the 60's. The latter years of the 1960's saw productivity growth decline to about half of what the rate had been. What bothers economists about this trend is the fact that "gains in productivity provide the chief source of rising planes of living in a country. In the United States, for example, over the last 50 years nearly all of the 2.4 percent a year average increases in living standards--or real income per capita--have come from increased productivity." (J. Kendrick, U.S. News and World Report, March 24, 1975) What is also bothersome is that productivity growth and our attempts to fight inflation are intimately related. It is not just a coincidence that the wage-price guideposts of past years have been based on productivity growth. For without productivity

increases, wages cannot improve without inflationary effects on the prices of goods and services.

Whether fiscal policy successfully grapples with inflation, unemployment, and the downward trend in our standard of living depends partially on the pervasiveness of factors beyond the control of policy makers--factors such as oil prices, the age composition of the population, attitudes, and so on. But if fiscal policy is to contribute towards ultimate solutions, the change in the very nature of the problems suggests the need for a new approach. The new approach has to place less emphasis on fighting wage-price problems by slackening aggregate spending (1) because the costs in terms of unemployment are, as we now see, extremely high; and (2) because if the consensus of opinion is correct, this method will be relatively ineffective in ultimately solving our inflationary problems. Since the solutions to the wage-price spiral and our declining standard of living appear to be intertwined with the problem of productivity growth decline, a new approach to "responsible" fiscal policy would include a closer look at the impacts on productivity growth of different Federal government expenditures.

Government Expenditures and Productivity Growth

The critics of government spending--particularly those writing in the popular media aimed at the business sector--take the position that government spending is counterproductive and that if anything, it exascerbates the problems of wage-price spirals and attempts at increasing the standard of living. They point most often to Federal welfare expenditures, First, they view these expenditures as providing disincentives to work. Second, they argue that these expenditures are financed by funds which, if left in the private sector, would in many instances lead to increased private investment. Thus, they concluded both the productivity of labor and capital decline as government spending increases.

There is some validity to this argument for certain classes of government expenditures, although the actual evidence is somewhat mixed on this question. But what is often ignored is that some of the great advances in productivity growth have been largely the result of certain types of government spending. The classic examples of government-induced productivity growth are in agriculture, where the gains have been considerable. Other examples are labor productivity gains through public education and numerous spinoffs (new products and production techniques) to the private sector from defense and aerospace reasearch efforts.

From the viewpoint of fiscal policy, it must be recognized that productivity impacts of government expenditures differ widely from one expenditure to another. With the current trends in productivity growth, these differences are of increased importance.

The Productivity Effects of NASA or Other High-Technology Programs

In the long-run, the economic impact of NASA's R&D expenditures and those of similar high-technology programs is to increase productivity, both through direct applications of aerospace technology (e.g., communication satellites, improved aircraft, etc.) and indirectly (but significantly) through the development and dissemination of advanced technology which is then applied in many other sectors of the economy. Indirect applications may be in "new" products and services (e.g., miniaturized calculators, heart pacemakers, video tape storage and retrieval systems, etc.) or in lower production costs for existing products and services (e.g., integrated circuits for electronic equipment in both products and processes, gas turbines for electric power production, cryogenic multilayer insulation, NASA's structural analysis computer program - NASTRAN - etc.).

In economic terms, NASA R&D and high technology programs have over the years led to significant increases in the economy's potential to increase both the level and mix of its total output (GNP). Increased capacity and improved technology lead to lower unit production costs and thus lower consumer prices. Lower final prices and improved quality of U.S. goods tend to help our balance of payments problems, since "relative world prices" and quality of product are important determinants of imports and exports. A specific example of this is the aviation industry. The high quality and performance of U.S. aviation products, coupled with favorable prices, have yielded an annual favorable balance of payments measured in the billions of dollars for many years. In 1974 alone, that figure was well over $5 billion.

In general, expenditure in NASA programs is compatible with the simultaneous satisfaction and achievement of the four goals of responsible fiscal policy, namely, full-employment, price stability, maximum economic growth and a favorable balance of payments.

Three major studies have been undertaken to quantify and document these productivity impacts of NASA expenditures. One study considers the benefits generated by four important technological spinoffs influenced by NASA research efforts. The other two studies quantify the contribution of NASA expenditures to productivity growth of the national economy. Although statistical estimates of the types obtained in these studies face a number of uncertainties, the studies are unanimous in showing a high favorable productivity effect from NASA R&D expenditures both in absolute benefits generated by specific technological spinoffs and in terms of overall rates of return. For example, estimates obtained by Chase Econometric Associates in their study The Impact of NASA R&D (forthcoming) show that a $500 million (1958 dollars) sustained increase in NASA R&D commencing in 1975 will increase labor productivity by approximately 1 percent by 1984. As a consequence of these productivity effects:

- the 1984 Consumer Price Index is lowered by 1.0 percent
- the unemployment rate in 1984 is lowered by 0.2 percent
- 1984 employment is increased by 400,000 workers
- Real GNP is increased in 1984 by $11.3 billion
- NASA R&D investment yields a 38 percent rate of return over the 10-year period.

Other results, as well as methods used in these studies are summarized in appendices to this report.

Other Considerations

The primary intent of this report has been to emphasize the importance of considering the productivity impacts of Federal government expenditures. This is by far the most important feature that differentiates NASA (and high technology expenditures in general) from other types of government spending. However, there are several features of NASA expenditures that also make them a relatively effective short term mechanism in reducing unemployment, and accomplishing this reduction in a non-inflationary way:

- NASA expenditures are labor intensive. About 85 percent of NASA spending goes directly to productive jobs and 15 percent goes for materials.
- There is significant unemployment, underemployment, and unused capacity in the aerospace industry. Thus, there would be no lag in putting people and machines to work.
- Every $100 million of NASA spending is equivalent of about 4,000 direct jobs per year.
- The short-term demand multiplier effect of additional jobs created indirectly in the community and the economy at large is significant and brings the total number of jobs resulting from each $100 million of expenditure to as many as 10,000 jobs.

At 10,000 employees per $100 million of expenditures, NASA is near the top of the list of Federal expenditures in terms of short run employment generation. These figures are based on contractor data and econometric estimates of the employment impact of the aerospace industry on the California economy. Moreover, these figures are corroborated by preliminary results of the Chase Econometric Associates' study, The Economic Impact of NASA R&D (forthcoming), which considers the short term impact of NASA expenditures within the context of the Chase Econometric model of the U.S. economy, as well as the long term productivity effects quoted above.

APPENDIX A

Summary of Findings of Economic Studies Measuring the Impact of NASA Programs on the Economy

In recent years, four major studies (UCLA, MRI, Chase Econometrics and Mathematica) have been made to measure and assess the macroeconomic impact of NASA R&D programs.

The UCLA Study

The UCLA study, using a macroeconomic model of the California state economy, examined the relationship between expenditure on the Shuttle program and additional employment in the state of California. The UCLA study estimated an employment multiplier of 2.8. The employment multiplier reflects the chain of activities set into motion by changing demand patterns. For example, the engineers, technicians, and others hired by Shuttle contractors and suppliers will respend a large fraction of their incomes on consumer durables and non-durables creating incomes for people completely divorced from the Shuttle program. These "other" workers will in turn expend their income on consumer goods providing jobs for people in both the state of California and other states. The employment multiplier of 2.8 was calculated by the UCLA study as follows:

would yield proportionately smaller quantitative effects; and transfers from NASA programs to other government non-defense programs would yield proportional effects in the opposite direction.

III. Major Conclusions

Chase found the following results:

a. Output - S $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. Inter-Industry 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 unemployed 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 one 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 non-aerospace industries, over a longer span of time.

APPENDIX B

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 inter-industry 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 inter-industry 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 non-defense programs to NASA programs, keeping the size of the federal budget constant. Transfers of smaller amounts

Direct Shuttle Employment, E_D (man-years) 95,300
Increase in Total Employment, E_T (man-years) 266,000
Employment Multiplier = $E_T \div E_D$ 2.8

An employment multiplier of 2.8 is unusually high and underscores the diverse impact that expenditure in this program has on even the most remote sectors of the California economy. The total U.S. employment multiplier of this program would even be larger because significant leakages of spending would occur from California to other states.

The Midwest Research Institute (MRI) Study

The MRI study may be divided into three separate but related approaches. The first approach was a case study of the process whereby technology is developed and commercially applied and of the several roles that a mission-oriented research and development agency such as NASA plays in that process.

The second approach consisted of a list of illustrations of the ways in which NASA undertakings have contributed to the Nation's scientific and technical knowledge reservoir. The purpose of this part of the study was to demonstrate that a large body of knowledge is accumulated in the process of satisfying mission-oriented program requirements and that this knowledge is retained for use by others for both private and other governmental purposes.

The third approach involved the development of an econometric model that focused on the U.S. economy during the last 20 years for the purpose of identifying and measuring the portion of economic growth which can be attributed to technological progress. The primary objective of this part of the study was to identify statistically the relationship between R&D expenditure and technological progress and then make a tentative estimate of the relative effectiveness of NASA R&D expenditures in generating economic growth via technological progress.

The MRI study concluded that technological progress was responsible for increasing non-farm output by 40 percent over the period 1949 to 1970. This finding is consistent with the findings of other studies made in both this country and abroad and supports the conclusion that R&D expenditures have been an excellent national investment. Assuming that NASA's R&D expenditures had the same pay-off as the average R&D expenditure, MRI found that:

> The $25 billion, in 1958 dollars, spent on civilian space R&D during the 1959-1969 period has returned $52 billion through 1970 and will continue to produce pay-off through 1987, at which time the total pay-off will have been $181 billion. The discounted rate of return for this investment will have been 33%.

Stated in simpler terms, MRI found that for every $1 invested in NASA R&D programs there would be a net return of over $7 over an 18-year period of time. However, MRI concluded that the 33 percent social rate of return on NASA expenditure was in all probability too conservative an estimate since NASA R&D dollars are allocated to the more technologically intensive industrial sectors of the economy that possess significantly higher than average productivity growth rates.

The Chase Econometric Associates Study

From the point of view of assessing the total macroeconomic impact of NASA expenditures on the economy, the Chase study is the most extensive study to date. The Chase study employs the most sophisticated econometric models available, namely, the 185 interindustry input-output model developed at the University of Maryland and the 200 equation macroeconometric model developed by Chase. Both models are widely used by government and private planners.

The Chase study was divided into two phases. The first phase is completed and the second phase is close to finalization. In the first phase of the study, Chase employed the input-output model to analyze the short-run economic input of NASA R&D expenditures. Chase found that "... NASA spending tends to be more stabilizing in a recovery period than general government spending." In addition, Chase found that "...a shift away from NASA programs 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." A more detailed summary of the methodology, assumptions and conclusions of this phase of the study appears in Appendix B.

The second phase of the Chase study, a study of the long-run effects of NASA R&D expenditures, may be divided into two parts. Part I was devoted to developing an aggregate production function. Specifically, this function would identify the relationship existing between NASA R&D expenditure and the rate of growth of productivity in the U.S. economy over the period 1960 to 1974, taking into account all other variables that would affect growth in productivity (e.g., "other" R&D expenditure, improvements in the quality of labor, additions to the capital stock, shifts in output mix, etc.). In this phase of the study, Chase found that the social rate of return on NASA R&D expenditure was 43%. (This supports MRI's contention that its estimate of a 33% social rate of return on NASA investment was very conservative.)

Part II of the Chase long-run study involved macro simulations over the period 1975 to 1984. The production function developed in Part I was assimilated into the entire Chase Macroeconomic model and all of the equations were solved simultaneously and checked for consistency.

The purpose of the simulations was to determine the direction and magnitude of the effects that changes in NASA R&D expenditures would have on the major economic indicators of growth and stability. Specifically, NASA R&D expenditures were increased annually by $1 billion (1958 dollars) over its "baseline" (current level) expenditures and the effects on the various components of GNP were observed over the period 1975 to 1984. Simulations involving $100 million and $500 million were also run and the results were found to be linearly consistent. Moreover, it was found that equivalent decreases in NASA expenditures would produce effects of exactly the same magnitude but in the opposite direction.

The major results of the simulations may be subdivided into the following four categories:

1. Effect on GNP (1958 dollars)

   A. Each $500 million in NASA R&D programs returns approximately $7.0 billion over a ten-year period. This is equivalent to a 38 percent rate of return over this period and, when later returns from this investment are included, the rate of return becomes 43 percent.

   B. A sustained annual increase in NASA R&D expenditure of $500 million commencing in 1975 would increase the level of GNP in 1984 by $11.3 billion.

   C. The accumulated additional investment of $5 billion over the ten year period will return $34.7 billion over that same period, and will continue to bring returns further into the future.

It should be noted that both the 14 to 1 ratio and the rates of return, stated in subsection A above, refer to only the increase in GNP resulting directly from the increase in productivity attributed to NASA R&D expenditure. Thus the 38 percent (or 43 percent) rate of return may be more properly viewed as a "special" (partial) rate of return relating only to productivity advances. And, in this sense, is unique to high technology programs.

The actual change in GNP will be larger (than $7.0 billion) due to demand multiplier effects that are common in nature (but not degree) to all expenditure. The results stated in subsections B and C above (and subsequent sections below) do take into account the interaction of both the demand multiplier and productivity effects of NASA expenditure on the level of GNP.

2. Effect on Employment
As a result of the sustained annual increase in NASA R&D expenditure of $500 million, the unemployment rate in 1984 is reduced by 0.2 percent.

The "actual" increase in employment will be 400,000. This effect is largely the result of only the first five years' increases in R&D expenditure because of realistic lag effects built into the model.

3. Effect on the Consumer Price Index (CPI; 1967 - 100)
Increased levels of NASA R&D expenditure will significantly lower the future level of CPI. The extent of the reduction in CPI is naturally a function of the extent of the increase in "earlier" levels of NASA R&D expenditure. For example, the Chase results show that a sustained increase in NASA R&D expenditure of $500 million commencing in 1975 will lower the 1984 CPI by 1.0 percent. This result may be better understood by considering the effect that NASA R&D investment has upon the Nation's average rate of productivity.

4. Effect on Productivity
The above cited effects on GNP, Employment, and Price Levels emanate from the significant effect that NASA R&D expenditure has upon the growth rate of the Nation's productivity. The results of the Chase study show a 1.0 percent improvement in the rate of productivity change in 1984 resulting from only a sustained increase in NASA expenditure of $500 million commencing in 1975. In short, the results of additional investment in NASA programs is to increase the rate of

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growth in productivity which is eventually translated into lower prices, higher levels of employment, and greater real income.

Conclusion

Although Chase and MRI note that there are a number of conceptual and data limitations to an aggregate quantification of the returns to the economy of R&D investment, the results of the Chase and MRI studies are consistent with the findings of other economic studies, both in this country and abroad; that is, that high technological endeavors, such as the space program, do result in disproportionately high rates of social return measured in terms of increases in GNP or national productivity.

The Mathematica Report

The Mathematica report estimated the national benefits from specific secondary applications of technological advances accelerated by NASA R&D activities. Using the "consumers' surplus" approach, the report provided estimates on a case study basis the cost savings resulting from improvements in cryogenic insulation, gas turbine efficiency, integrated circuits, and the development of the NASTRAN computer program.

The report methodology is fairly straightforward. The benefit arising from a particular technological advance is identified with a fall in the price of a factor input. Under various assumptions, the report shows that this "surplus to the producer employing the factor" is identical to the aggregate consumers' surplus in the final demand market. Therefore, it is argued that the benefit of a particular technological advance can be estimated at the factor market which involves the new technology. Once this benefit based on the concept of surplus to the producer is calculated, the benefit of NASA's involvement is then calculated as the difference between the present value of two benefit streams, one beginning at the actual time of invention or innovation with NASA's involvement, the other at the estimated time without NASA's involvement. The following benefits (1974 dollars) were attributable to NASA:

	Most Probable Benefit Est. (Millions)	Benefit Interval
Cryogens	$1,054	1960-1983
Gas Turbines	111	1969-1982
Integrated Circuits	6,175	1963-1982
Nastran	357	1971-1984

IMPORTANCE OF INVESTMENT IN RESEARCH AND TECHNOLOGY

Dr. FLETCHER. Finally, although this seems like a rather bleak year because of continuing budget decreases in terms of constant dollars, NASA continues to strive toward a broader participation in the scientific exploration of space and also toward extension in the practical applications of space. And in aeronautics we have moved into technology efforts which focus on improved efficiency and performance, and I think this will certainly have a beneficial economic impact.

The fiscal year 1977 budget is not all that we would have liked it to be, but it does provide for a measured progress toward our objectives in space and aeronautics. But this is one more year of holding the line. We will be able to continue to work toward accomplishments in aeronautics and space, but at a somewhat slower pace. Nevetheless, we fully remain committed to that goal of moving ahead in space and aeronautics, even with this reduced budget.

Let me emphasize this final point.

We must continue to invest adequately in the future by investing right now in research and advanced technology. National productivity, efficiency, and the ultimate well-being of this country do depend upon these expenditures, and continued erosion of NASA's research and technology efforts, either by underfunding or by repeated squeezes or by inflation, is undercutting the viability of the entire program, and it is simultaneously foreclosing important opportunities for the Nation's future.

Over the past few years, the funding patterns have threatened to reduce to a trickle the flow of new advanced technology, which I think is so very vital to our economy. I hope that this trend will not be permitted to continue, and that NASA's programs in aeronautics and in space will in the future receive the full support that they clearly deserve on their own merits.

This concludes my statement. If you wish, we'll proceed right on with Dr. Low's presentation.

Mr. BOLAND. We will be pleased to hear that.

Mr. YOUNG. Mr. Chairman, would it be out of order to ask Dr. Fletcher a general question?

Mr. BOLAND. There is nothing out of order in this subcommittee.

PRODUCTIVITY AND EFFICIENCY

Mr. YOUNG. He made a statement, which I found very interesting, about improving efficiency and performance. I wonder if we could ask him to say something more about that.

Mr. BOLAND. Why don't we get into that. It is an important statement. As Dr. Fletcher indicated, they prepared a paper with respect to the increase in productivity; that it does depend upon the development and application of advanced technology. NASA is on the cutting edge of advanced technology; and so this may be a good time to explore that.

Mr. YOUNG. I think any time we can improve on efficiency, we ought to know about it.

Dr. FLETCHER. The way the economy grows is by efficient utilization of people and by effective investment of capital. But unless that capital is invested in new, innovative ways with new technology, you don't

actually increase the output per person; you simply continue to produce what you have always produced, and you don't do it more efficiently. It is by improvements—I will call them inventions, if you like—derived from this new technology that the country actually grows. The sum of the growth is not only the increased capital, but also increased employment and increased GNP based on increases in efficiency.

APPLICATION OF NASA HIGH TECHNOLOGY

Examples of this are better machinery and new electronics. The best recent example is perhaps the small, minicomputers. Those of you that used to use those old calculating machines that run mechanically now can buy a hand calculator for less money, but they work a lot better as well. That is an example of improved efficiency, based squarely on technology, and it is this kind of technology that's being fed into the economy. It is not just in computers, it is in every walk of life. It is in medicine; it is also in energy fields. For example, we have better ways of dealing with natural gas. People are using more natural gas because it now can be stored cryogenically in liquid natural gas storage facilities. Much of that cryogenic technology came right out of the space program.

We are also beginning to use gas turbines in the generation of power. Most power companies throughout the country use gas turbines. Much of that gas turbine technology came out, again, of the space program, especially the high temperature gas turbines.

A number of studies have been made of this high technology "feed through" recently. We had one made by Mathematica in Princeton. The authors are Princeton University economists, by and large, and they showed that NASA technology has had an enormous impact in the following fields: Cryogenic technology—that is liquid fuels; in microelectronics—that is computers and various kinds of electronics; in gas turbine technology; and another one which you don't see very much of because it is used by large industries, and that is improved structural design.

Even the automobile industry, for example, has used a lot of NASA technology in the design of their automobiles. We have a program called NASTRAN which is used by companies such as Chrysler, Ford, and General Motors. NASTRAN is used by all three of these companies to design improved structures of higher strength for their automobiles.

All of this technology moves into the economy in a major way. If we cut back on the technology, we are not going to have so many new inventions or innovations.

CHASE ECONOMETRICS STUDY

Recently we decided to have a banking group look at technology as it bears on the macroeconomic picture. Bankers are about the most conservative group in the country, and we wanted a conservative study. Chase Econometrics studied all these aspects, and came to the conclusions that I mentioned earlier; namely, if you invest in NASA high technology now, you create immediate productive jobs, without increasing inflation, because there is existing aerospace plant capacity that is underutilized now, and there is also underemployment in this

field. You not only generate immediate employment but in the long run you also create the technology that will make the economy grow and become increasingly productive and efficient. As a result, in the future you create an enormous number of jobs. I personally am convinced that investment in this kind of technology is going to be the ultimate salvation of this country's economy and well-being.

That was the conclusion of the Chase Econometrics study. We did have that available last year, but I think the updated executive summary will be available soon, and we will be glad to submit that for the record as soon as it is available.

Mr. BOLAND. Of course, you are not the only people in the field of advanced technology. There are a lot of others in this area, too. I don't know that you could attribute to NASA all of the improvements that have come in advanced technology which have resulted in greater productivity.

The amount of money that's being spent by the various armed services and by other agencies of the Government and private enterprise also contribute to these improvements.

Mr. ROUSH. The Department of Agriculture, for example.

Mr. BOLAND. And the Department of Agriculture, we would be doing this without NASA, anyhow, wouldn't we?

Dr. FLETCHER. Mr. Chairman, you are absolutely right about the first part of your statement. Overall advanced technology is necessary for the growth of this country; NASA contributes a good portion of that total.

If you look at defense, it is a fairly large expenditure. However, if you look at the part that is advanced technology, it is not much larger than NASA's.

It depends upon definitions. Agriculture is also investing in technology, but they are using a lot of the NASA technology. Much of the technology that is being transferred into many various segments of the economy comes out of NASA. Technology is important in agriculture, and we need to improve efficiency in agriculture, but a great deal of the information that comes out of the NASA programs goes into agriculture, too. I will use an example that some of you may be familiar with. A great deal of the planning and fertilizing of large agricultural plots is done by aircraft. I am not a farmer, but I was amazed to find out how much of that was done from the air. They fly over the land, and they can seed, fertilize, and spray for weeds entire tracts of land. This is done all over the country. If we could improve aircraft, which we are doing, to make this more efficient, we could save a sizable amount of the cost in agriculture.

There are other places where high technology investments can and should be made. I support all these efforts.

NASA itself is one place that ought to be looked at as a logical place to invest in that high technology.

NASA AERONAUTICS TECHNOLOGY

Mr. YOUNG. I understand exactly what you are saying in the general context of your remarks; but I was wondering about specifics.

You say, for example, that we are making these improvements in aircraft.

Could you give us some examples of what you are doing, or what we could expect to see?

Dr. FLETCHER. Yes, Mr. Young, we can. Dr. Low is going to explain it, but he happens to have some models here, and I will use these models.

For instance, here are two wings. This is for commercial aircraft and not for agricultural aircraft, although the same thing could be done for an agricultural aircraft. One is made out of the traditional aluminum; another one is made out of composite material which is being developed in NASA. This composite material is gradually being used on commercial aircraft but not yet on a wing. If we used this composite wing on all commercial aircraft in this country—and you can look at these if you wish—instead of aluminum, we would save enough fuel so that all of the airline companies in this country would have made a profit this last year instead of a loss. You can feel the difference in the weight of those two wings.

That is an example of the technology we are talking about. It came right out of the NASA technology, and it is part of our aeronautics research and technology program.

Mr. BAUCUS. Why don't we have it then?

Dr. FLETCHER. We will.

Mr. BAUCUS. When?

Dr. FLETCHER. Dr. Low will be discussing this subject during his presentation. However, he will be glad to comment on your question.

Mr. TALCOTT. With this type of technology would Eastern and Pan Am, for instance, have made a profit?

Dr. LOW. Yes, sir. On the profit, we just estimated it in total. If U.S. airplanes were using this kind of technology today in the wing alone, and nothing else were changed, the companies would have saved enough money on fuel to make a profit instead of a loss last year. In response to your question on when it would be available, the answer is probably on the next generation of airplanes to be built, in the early 1980's. It takes time to get from the laboratory to the airplane itself. It takes time to demonstrate to airlines, and the people who certify airliners, that this kind of technology is safe for flight.

NASA is working today on providing the test program to demonstrate the safety.

Mr. YOUNG. Dr. Low, what you're saying when you say they could have made a profit is that they would have reduced fuel consumption; is that correct?

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

Mr. YOUNG. And by what factor would the fuel consumption be reduced?

Dr. LOW. The total of all technologies that we are working on, which I will discuss in a little while, could ultimately save up to 50 percent of the fuel used for airplanes.

The composite wings alone would save on the order of 5 percent of the fuel used by today's airliners. Just the single factor of making an airplane light enough so that you don't have such a heavy structure would cut fuel consumption by 5 percent.

Mr. TRAXLER. What material is the composite made of?

Dr. LOW. This particular material is made of a graphite epoxy. It is carbon fibers bound in a glue, just like a fiberglass boat is made, but instead of fiberglass, graphite is used.

POTENTIAL APPLICATION OF NASA TECHNOLOGY TO AUTO INDUSTRY

Mr. TRAXLER. Obviously, it has implications for other industries.

Dr. FLETCHER. It certainly does. The auto industry is a good example. When the auto industry starts using the composites, autos will not only be safer, but they will also be lighter and use less fuel. But, of course, that takes time, too.

Mr. TALCOTT. Except it might be like a Corvette. When you have an accident with a Corvette you have to get a whole new body because you can't repair it the way you can aluminum or metal.

Dr. LOW. These graphite epoxies are much stronger than the fiberglass that is used on boats or on Corvettes. That is why they are particularly good for use in airplanes, because of the stiffness and durability.

Mr. TALCOTT. Is one of the problems the risk or danger to life with fires in accidents?

Dr. FLETCHER. No, Mr. Talcott, not fire and accidents.

The auto industry is deciding how to use the composites—whether to use them in small pieces or in whole bodies—and their approach would determine whether it would be more or less expensive.

I should add one other point, though—the fiberglass composites have a little more give than metals, and so they don't buckle quite the same way.

Dr. LOVELACE. The composite materials are twice as strong as aluminum. They are four times as stiff, and weigh half as much.

We have, in fact, been discussing this subject and working with General Motors, Chrysler and Ford. I think it is a very safe prediction to tell you that very shortly you will begin to see this class of materials enter the automotive indutry and that will have a significant beneficial effect on that industry and for fuel conservation. I think that it will allow the auto industry to produce a cheaper, more competitive product. And it will, in turn, reduce the cost of the materials so that all aspects and all segments of the industry will benefit.

Mr. TRAXLER. Why do you say a cheaper product?

Dr. LOVELACE. Because it is less labor-intensive; it is certainly less labor-intensive in aerospace applications where you are accustomed to aluminum construction. There is a lot of riveting, bolting, etc., and the man-hours per package, per pound of structure for an aluminum structure, is much higher than it will be with composite structures.

Mr. TRAXLER. You are going to be very popular with Exxon and United States Steel.

Mr. ROUSH. Are the materials in plentiful supply, that go into this particular structure?

Dr. LOVELACE. The graphite is potentially a very cheap product. The base glue or adhesive, as Dr. Low referred to it, is a petroleum-based product at the moment. However, it is very much available, and it is not an energy intensive process, either, even though our traditional basic metal-working processes are energy-intensive processes.

POTENTIAL AIRCRAFT FUEL SAVINGS

Mr. YOUNG. Dr. Low, you accounted for 5 percent of that 50 percent fuel savings by using the new material.

I would like to know where you are going to get the other 45 percent.

Dr. Low. There are a number of technologies, Mr. Young, that are involved in reducing fuel consumption of airplanes.

One is the structural materials. A second is the shape of the wing and the fuselage. If you can shape it in a different way, you can reduce the resistance of the airplane flying through the air. This in itself would result in fuel savings.

A third is in the powerplants, that is the engines. We have two projects underway; one to improve the fuel efficiency of existing powerplants; a second to move out with new powerplants that are even more efficient; and finally we are looking at very advanced ways of keeping the flow over the wings smooth and not letting it become turbulent. This, again, will improve the efficiency.

When we add up all of these increased efficiencies, we would have potential fuel savings for aircraft, incorporating all of these technologies, of up to 50 percent.

Mr. YOUNG. It sounds exciting. I hope you are successful.

Mr. TALCOTT. You people have the facility of astounding us more than almost any other agency. But the thing that is the most astounding to me is that you have been almost precisely accurate in all these astounding predictions, even to landing on the moon within a few seconds of when you said you were going to 8 or 9 years in advance. It is pretty hard for us to believe the things that you tell us all the time, except that they keep coming true.

Dr. FLETCHER. I hope I am wrong, Mr. Talcott, in my predictions of the economy. But my predictions are that unless we start investing more heavily in advanced technology now, we are not going to experience the growth that we have in past years.

NASA AS PERCENTAGE OF FEDERAL R. & D. BUDGET OUTLAYS

Mr. TALCOTT. Actually, the administration's budget for fiscal year 1977 does have an increase in research and development.

Dr. FLETCHER. It has some, but not really in the NASA area. We have, as I mentioned, a very small increase. The R. & D. increase is primarily in DOD, the National Science Foundation and ERDA.

As a matter of interest, Mr. Talcott—and this was coincidence, last night we happened to look into how NASA investment in technology compared with the rest of R. & D. in the Federal Government. The curve shows that NASA, as a percentage of Federal R. & D. budget outlays has dropped from 35.7 percent in fiscal year 1966 down to about 15 percent of the total in fiscal year 1977. The investment in NASA high technology is going down as a percentage of the Federal R. & D. budget outlays.

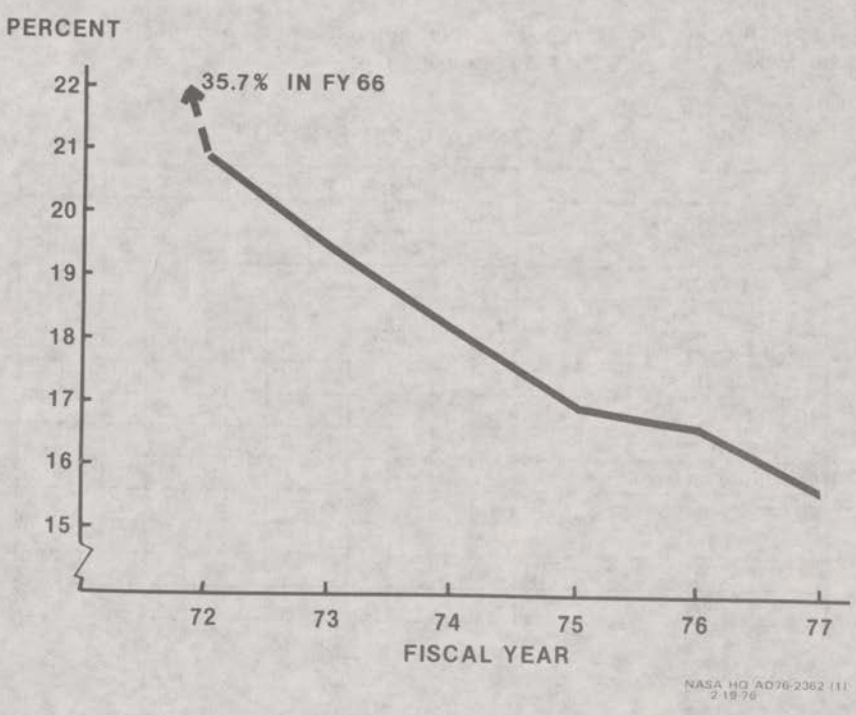
Mr. TALCOTT. Perhaps this graph should be in our record.

Dr. FLETCHER. We will be glad to do that, Mr. Talcott.

Mr. TALCOTT. I think it should be in the record.

[The information follows:]

NASA AS PERCENTAGE OF FEDERAL R&D BUDGET OUTLAYS



Mr. TALCOTT. You know, Exxon and the steel and aluminum companies did not care anything about the wood products replaced with various metals and plastics, such as those in airplanes. So I do not think we should worry too much about Exxon and United States Steel. They will catch up in some other way.

Mr. TRAXLER. I tend to agree with you, Mr. Talcott. I am sure that Exxon and United States Steel will take care of themselves.

Mr. BOLAND. I suppose the bigger worry is whether the aircraft industry can start from scratch to build a new fleet of composite-based aircraft; and should the aircraft industry do this. Last year, the estimate for composites was around $4 million in this activity. This year you are requesting $16 million, four times more. That is a lot of money.

Dr. FLETCHER. Mr. Chairman, perhaps this would be a good time to have Dr. Low's presentation, because it addresses that specifically.

There is more to it than just the fuel savings. There is increased efficiency and productivity. It involves, again, the strength and growth of the whole economy.

Mr. BOLAND. We will be very pleased to hear Dr. Low.

NASA PROGRAM HIGHLIGHTS

Dr. Low. Could I have the first slide, please?

1976 NASA LAUNCH SCHEDULE

I will come to aviation in a few moments, but I would like to start with the NASA launch schedule for 1976.

NASA 1976 LAUNCH SCHEDULE

	J	F	M	A	M	J	J	A	S	O	N	D
COMMUNICATIONS												
U. S. DOMESTIC			△		△			△		△		
U. S. MARITIME		△			△							△
INTERNATIONAL	▲											△
FOREIGN REGIONAL				△			△	△				
EXPERIMENTAL	▲				△							
WEATHER									△			
NAVIGATION						△						
EARTH/OCEAN DYNAMICS				△								
SCIENCE	▲				△							

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FIGURE 1

We have 19 launches planned in 1976—about the same as last year. Three of them have already taken place in the month of January, and all three of those launches were successful. The fourth one is coming up tomorrow night, which will be a satellite for U.S. maritime communications.

The interesting feature about this year is that perhaps we should call it the year of the communications satellite. Fourteen of the nineteen launches planned are communications satellites: four domestic and three maritime communications satellites; two international ones; three foreign regional ones; and two experimental ones.

This is another indication of the kind of thing we have been talking about for the last 2 or 3 years, that space is a way of life. The indications are that the predictions we have made for the use of the Space Shuttle in the future are coming true—people are beginning to use space more and more. In the case of communications, the companies are finding it more economical and more efficient to use space satellites than any other way of doing business.

Out of the total of 19 launches this year, only 2 will be totally for NASA itself, one an Earth/Ocean dynamics satellite and the other an experimental scientific satellite. In this time period, two more are cooperative missions with other nations. But 15 of the 19 launches are for commercial organizations, other nations, or other Government agencies. For example, the Weather Service is launching a weather satellite in September of this year.

Mr. ROUSH. Dr. Low, what type of orbit will these satellites be in? How many of them are in synchronous orbit, for example?

Dr. LOW. The communications satellites are all in synchronous orbit.

Mr. ROUSH. Then the Space Shuttle could be used to service those satellites; could it not?

Dr. LOW. The Space Shuttle will be used, with an upper stage, to place those satellites into a synchronous orbit. Later on, if refurbishment proves feasible and economical, we would proceed with something called a space tug, which would also allow refurbishment in higher orbit.

Mr. ROUSH. That probably will be beyond the life of these satellites?

Dr. LOW. It would be beyond the life of the satellites that are being launched now. The remaining satellites are generally weather satellites and navigation satellites all in lower Earth orbit.

Mr. BAUCUS. Are any of them military?

Dr. LOW. We are launching two communications satellites this year for the North Atlantic Treaty Organization. We are not showing on this chart generally the U.S. defense space program, which is a separate program with its own launches.

However, when the Shuttle flies, the Defense Department will also use the Shuttle for its own launches.

NASA BUDGET PLAN

Dr. Fletcher has already mentioned the total budget figures, and we will, of course, be discussing each of the projects in detail today and tomorrow. So I will not now discuss the budget in detail. You can see the NASA budget plan summarized here.

NASA BUDGET PLAN
(Millions of Dollars)

	FY 76	FY 77
AERONAUTICS	175.4	189.1
SPACE TECHNOLOGY	74.9	82.0
SPACE SCIENCE	434.2	379.0
APPLICATIONS	178.2	198.2
SPACE FLIGHT	1560.5	1644.7
TRACKING AND DATA ACQUISITION	240.8	258.0
ENERGY TECHNOLOGY APPLICATIONS	5.9	-
TECHNOLOGY UTILIZATION	7.5	7.9
TOTAL RESEARCH AND DEVELOPMENT	2677.4	2758.9
CONSTRUCTION OF FACILITIES	82.1	124.0
RESEARCH AND PROGRAM MANAGEMENT	795.5	814.1
TOTAL BUDGET PLAN	3555.0	3697.0
TOTAL OUTLAYS	3517.2	3676.0

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FIGURE 2

I did want to make one point, however. This has to do with what we call energy technology applications. This year, in fiscal year 1976, we had almost $6 million in this area. In the fiscal year 1977 budget request there are no funds for NASA energy technology applications.

We have been identifying and refining NASA-developed technology, with NASA funds, to determine whether we could come up with effective energy programs to help to solve critical national needs. Examples include the application of space technology to solar heating and cooling; the application of space technology to wind turbogenerators or windmills. We used this money, then, as "seed money" to determine feasibility. If a project turned out to be feasible, the Energy Research and Development Administration (ERDA) would then take over and spend its money, often through NASA, to continue with this work. In fiscal year 1976, ERDA will be spending about $40 to $50 million, through NASA, and this reimbursable activity will probably be more in fiscal 1977.

It was an administration decision, as part of the fiscal year 1977 budget process, not to request NASA-direct energy R. & D. seed money in fiscal year 1977. Any of this work would, as a result, have to be funded by ERDA.

NASA BUDGET TRENDS

Turning to NASA budget trends, I thought it would be worthwhile to go over a brief budget history to show where NASA has been and what we are trying to do with the rather limited funding in this fiscal year and in the past 7 years.

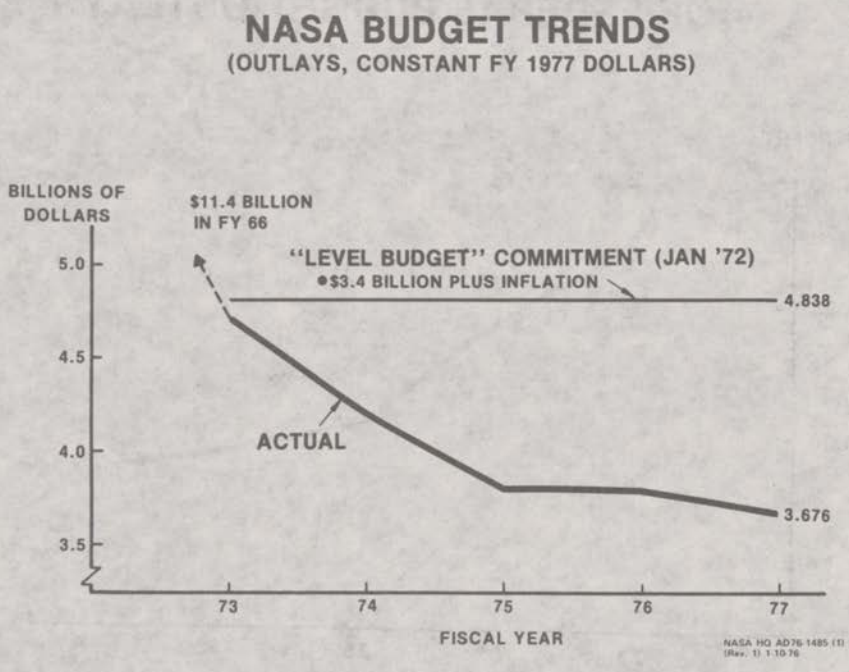


FIGURE 3

At the time we started the Space Shuttle, which was the beginning of fiscal year 1973, we made a commitment to the administration and to the Congress that we could carry out a balanced space program, including the Space Shuttle, for what was then a constant level budget of $3.4 billion, plus inflation. If we had stayed at this level, because of inflationary trends we should be at $4.8 billion by today.

What has actually happened is that, year by year, our outlays continued to decrease in terms of fiscal year 1977 constant dollars. As a result, NASA outlays for fiscal year 1977 will be about $3.6 billion, more than $1 billion below where we thought we would be at the time the Shuttle was started.

By the way, this $1.2 billion difference represents over 100,000 jobs that could have been generated in the economy from this high technology aeronautics and space activity that are now no longer there. This is the total employment impact on the localities and the economy as a whole.

Now, we are trying to hold our own. We are presenting a fiscal year 1977 budget that is still a reasonably well-balanced program, but it is much less of a program than we had hoped to bring before you in this period—about $1 billion less. Therefore, we are doing far fewer things in space and aeronautics than we feel—or we felt in 1972—that we should be doing at this time.

NASA AS PERCENTAGE OF FEDERAL BUDGET OUTLAYS

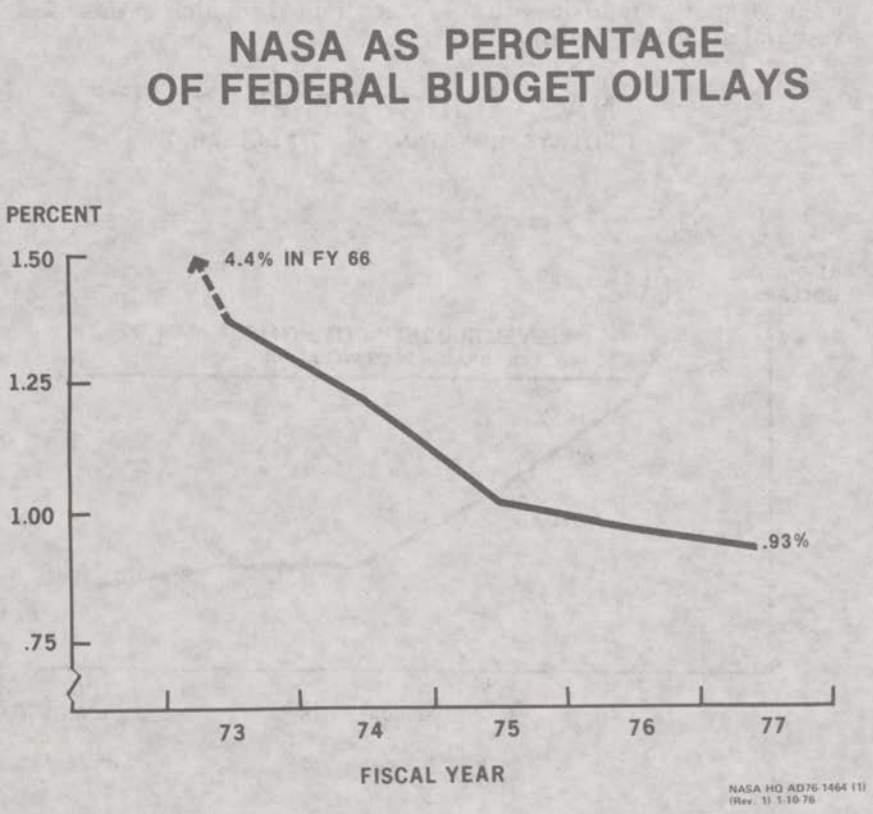


FIGURE 4

This chart shows the trend as a function of total Federal spending. At the peak of the Apollo program, in fiscal year 1966, NASA was 4.4 percent of the Federal budget outlays. At the time the Shuttle was started, we were down to about 1.3 percent. This year, we are presenting a budget that is down to less than 1 percent of the total Federal spending.

NASA "IN-HOUSE" PERSONNEL

In order to carry out the program and to run a space and aeronautics program at this low level, we have had to do a great deal of internal belt-tightening. What I have shown here is what we call the in-house work force, which was at almost 80,000 at the peak of Apollo and

which went down to about 58,000 in fiscal year 1971. It is down this year to 45,751 for fiscal 1977.

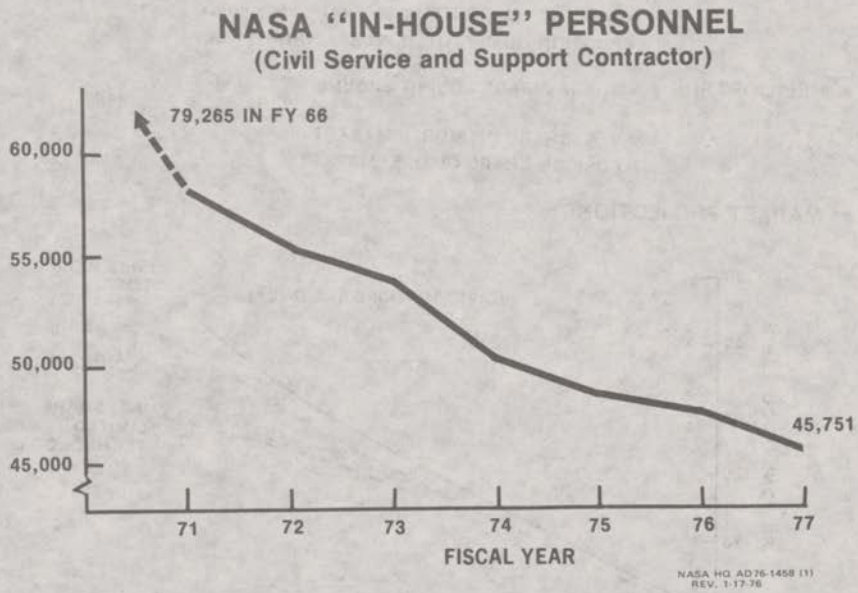


FIGURE 5

Now, this is the result of a tightening up through a very detailed institutional assessment in this past year. We looked at every function in every one of our centers. We reassigned some jobs; we refocused efforts; and we volunteered a cut of an additional 1,622 NASA in-house personnel from the end of fiscal year 1976 to the end of fiscal year 1977.

I do not know of any other Government agency that has done this kind of intensive self-examination and cutting back of its own work force in order to carry out the best possible program.

We consider ourselves to be efficient. We like to run a tight ship and be, as I say, mean and lean. I think we have achieved this, and the NASA programs, which I will discuss in a moment, will demonstrate this.

AVIATION FACTS

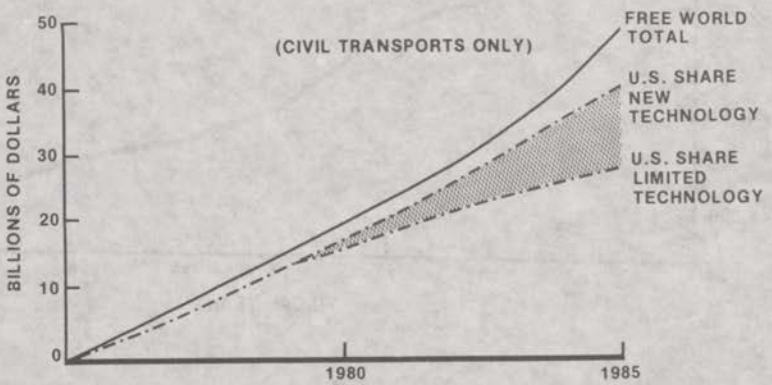
Let us now get back to aviation.

AVIATION FACTS

- **CIVIL AIRCRAFT**
  - 78% TRANSPORTS ARE U. S. BUILT
  - $6 BILLION EXPORTS IN 1975 (Aircraft, engines, parts)
  - FOREIGN COMPETITION INCREASING RAPIDLY
- **HELICOPTERS**
  - U. S. ALREADY LOSING GROUND

	1965	1975
• U. S. SHARE OF WORLD MARKET	80%	40%
• FOREIGN SHARE OF U. S. MARKET	5%	20%

- **MARKET PROJECTIONS**



- **NEW TECHNOLOGY NEEDED TO CAPTURE NEXT GENERATION AIRCRAFT SALES**

FIGURE 6

We touched on this a few moments ago, but there is more involved in what we are doing in aeronautics than merely saving fuel. I think that the aviation industry is providing a major economic benefit, to the United States. Let me tell you why.

BALANCE OF TRADE

If you talk about civil aircraft alone, 78 percent of the transports worldwide, except for the Soviet fleet, are built in the United States. That represented last year, in calendar year 1975, 6 billion dollars' worth of exports for aircraft, engines, and parts; $6 billion flowing into the United States. But foreign competition is increasing rapidly.

These are not idle words. There are orders for the European airbus that we see and watch day by day. Many countries that did not even have airlines before are buying the European A–300 instead of 707's or DC–8's or 727's or DC–10's.

The American industry is beginning to lose ground.

I can give you specific statistics for helicopters. In 1965, the U.S. share of the world market was 80 percent; today it is down to 40 percent. The foreign share of the U.S. market was 5 percent in 1965; 10 years later, it is up to 20 percent.

Mr. TALCOTT. Is that the civilian market?

Dr. Low. That is the civilian market. There is a comparable story for the military market, except that the exports are not nearly as high for the military market as they are for the civilian.

POTENTIAL SALES MARKET

If you look ahead into the future—and I think we had a question about this a while ago, we predict, and it is a rather conservative prediction, that there will be on the order of 50 billion dollars' worth of sales worldwide for civil transports alone. In other words, even though there is a current slump, and even though American airlines, United States carriers, are currently oversupplied, with any kind of growth worldwide, this business is going to pick up again rather rapidly to provide 50 billion dollars' worth of sales within the next 10 years.

Now, if we maintain our share of the market, 78 percent of the airplanes, which amounted to about 90 percent of the cost because we sell larger airplanes overseas, we could bring into this country about 40 to 50 billion dollars' worth of that.

IMPORTANCE OF TECHNOLOGY ADVANCES

However, it takes new technology to maintain the share of the market. If we fall behind in technology and our airplanes are less productive than what the foreign competition sells, we are going to begin to lose out rapidly. We estimate that we could lose about $15 to $20 billion of that 1985 cumulative market.

Mr. Talcott. Dr. Low, I am not sure that I understand your graph over here, in 1970, starting at the zero.

Dr. Low. This is a cumulative curve, Mr. Talcott. This means airplane sales, year after year. By 1985, it would be $50 billion.

Mr. Talcott. That looks like you had zero billions of dollars of sales at the early point.

Dr. Low. The projections build up from 1975.

Mr. Baucus. How did you arrive at this spread in 1985?

Dr. Low. Between new technology and limited technology? It represents the best estimate that we can get from talking to economists, airline company people, and airplane manufacturers.

Mr. Baucus. Could you give us some examples? A little more detailed reasoning as to how you got that?

What do they say?

Dr. Low. If you ask one of the major airplane companies, what would it take to be able to sell an airplane, say in 1980 or 1982, in competition with what Europe will be building in the same time period, the answer is a demonstrated, advanced technology.

We asked the chairman of one of the major aircraft companies whether he would put one of these composite wings on the next generation of airplane. He said that today he could not; but by 1980 he could, if enough work is done to demonstrate that this technology is really feasible and economical to fly.

If the manufacturer can sell a more productive airplane than the European competition, he expects to capture that market. If he sells today's technology—if he sells a 727 or DC–9 in competition with

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the advanced European airbus, which is now on the drawing boards—he cannot compete.

Dr. FLETCHER. Could I just add one point here?

One of the points is that most of the current line of airplanes, are reaching the end of their normal lifetime. As a result, airlines throughout the world are looking to which airplane is going to replace existing ones.

A while back, they would have said they want one that goes faster and carries more passengers and so forth. That is still true, but because of the energy crisis, they are also saying they want one that does not use as much fuel. Therefore, to be competitive in terms of replacement aircraft, we have to be ahead of the Europeans in how fuel efficient our airplanes are per passenger mile.

Mr. BAUCUS. What are the major non-U.S. airplane manufacturers?

Dr. FLETCHER. Aerospatiale is a large company in France. They, with British Aircraft Corp. in Britain, make the A–300 airbus. They also make the Concorde.

And the airbus is one of the most competitive airplanes. It carries, right now, something like 250 passengers and is very economical on the short haul. That would be a good competitor for whatever we want to offer to replace the 727's.

It is being used not only in Europe, by the way. Many developing countries are also buying European aircraft instead of U.S. aircraft.

Mr. BAUCUS. Why?

Dr. FLETCHER. Because they are becoming as good as American made airplanes.

Mr. TRAXLER. Are the French companies owned by their government, or are they private stock companies, or a combination of both?

Dr. FLETCHER. I will have to defer to Dr. Lovelace.

Dr. LOVELACE. They are private companies, but they are subsidized very heavily in both the United Kingdom and in France by the Government. In fact, their developments are underwritten. The aircraft that we discussed earlier—the A–300, the Concorde—and future civil aircraft developments will have the development costs underwritten by the respective governments. That is at variance with our practice in the United States, where at best we have shared technology with our industry, and they have worked in the private sector to raise the funds for development and manufacture.

Mr. TRAXLER. I think it should be noted that there are some other considerations as to which aircraft company gets the contract. There are political and international relations aspects which we do not know. We could have superior aircraft, but for international relations or political purposes there may be decisions made which we cannot project.

Dr. FLETCHER. Mr. Traxler, you are absolutely right. All we can project is what the difference will be with advanced technology, and without it. There are many other factors that will determine how much of those aircraft we sell.

Mr. BAUCUS. Is the Soviet Union not going to sell commercial aircraft in the future?

Dr. FLETCHER. I do not know the answer to that question. Maybe Dr. Low does, but our biggest competition will be from Europe in the next 10 years ahead.

Dr. Low. To my knowledge, so far the Soviet Union has not been at the point where they have had the kind of equipment that they were willing to subject to the Western World's certification. There is a very difficult hurdle to get over before an airplane can fly commercially in the Western World. The Soviets have not subjected their craft to those tests. I think they will eventually, though.

Mr. BOLAND. Has one of the problems been with respect to their aircraft cost and the ability to sell them? Has one of the problems been that the aircraft industry itself has put its investment dollars in the wrong place over the past 10 years? You know, the aircraft industry has invested millions and millions of dollars in the wide-bodied jets, the L–1011 and others. Now they are taking them out of usage and storing them, or selling them to foreign countries.

The Pacific Southern Airways has, I think, come to the conclusion to discontinue the use of L–1011's, and has gone to the Lockheed propeller craft for intrastate travel.

Dr. Low. Mr. Chairman, I think it is quite true that the airlines, the airplane industry, did not anticipate the economic slump, and they predicted growth in the airplane industry considerably larger than has occurred over the past 4 or 5 years. Therefore, they overbuilt in terms of fleet size and size of the airplanes.

Mr. TALCOTT. There must be a lot of other factors we are not including in here—the cost of labor and materials and fuels, in changing back from a jet to a propeller-driven aircraft. The pilot that gets $75,000 a year to fly a jet, and only $30,000 to fly a propeller-driven aircraft. There must be really dozens of factors that go into the operation of an airline, as well as the production of aircraft. With our high cost of production we are certainly going to lose out to the Europeans if they have lower cost of production, particularly if they develop the new technology. If they get a better airplane, no matter what the political factors are, if there is a better airplane, I bet the airlines in those other countries are not going to pay too much attention to politics. They are going to get the cheaper, better airplane.

Dr. Low. That is true. Ultimately, they will buy the airplane which gives them the best return on investment and the lowest operating cost over time. And the only way that we know to lower that operating cost, given fixed labor cost and everything else, is to increase the technology. That has a very dramatic effect.

Mr. TALCOTT. That technology advantage is the only thing we have left. We are not going to reduce labor costs. I think the handwriting is on the wall. We are not going to do that. But in terms of technology, we do have a great potential there.

Dr. Low. We can help to make the construction of an airplane less labor-intensive through the application of technology, and we can increase the efficiency by increased technology.

AVIATION GROWTH 1940–2000

Here I have shown the direct relationship—which came out of our new study called "Outlook for Aeronautics," about to be published—between R. & D. investment in the United States, NASA, DOD, and industry.

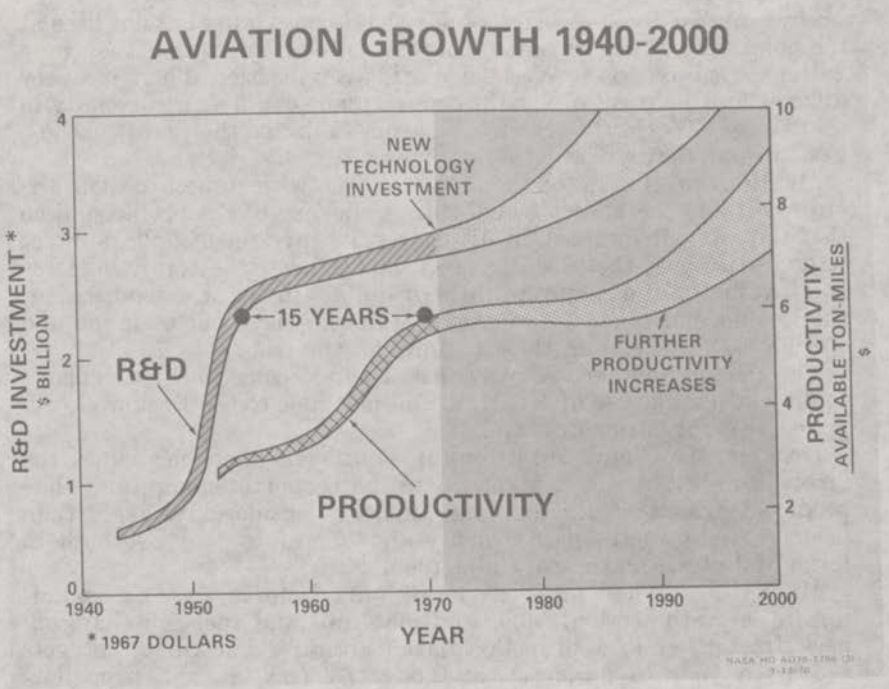


FIGURE 7

I have related to that the productivity of our airplanes measured in available ton-miles.

The main point here is this productivity curve follows in shape almost exactly the R. & D. investment curve, with about a 5- to 15-year lag, depending upon the technologies that are being used. I think it is a very interesting demonstration that there is this direct line between the productivity, and therefore the cost of operating an airplane, and the R. & D. investment that goes into this aircraft industry.

AIRCRAFT ENERGY EFFICIENCY TECHNOLOGY

As Dr. Fletcher has already mentioned, what happens to be important in terms of productivity today is fuel consumption. Those technologies that increase the efficiency of the airplane, and lower the fuel consumption are efforts which increase most rapidly the productivity of the airplane, because of the very high fuel cost today.

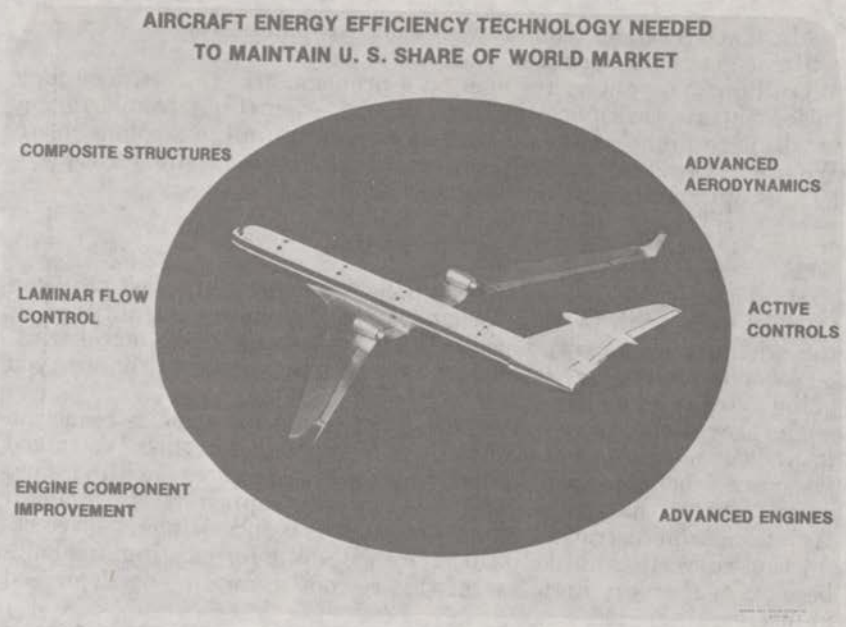


FIGURE 8

These are the factors that we discussed before: The composite structures in the wings, that we showed you; laminar flow control to reduce the resistance of flying through the air; engine component improvement; advanced engines; different shapes for the wings and for the fuselage called advanced aerodynamics; and control systems that fly the airplane for much of its flight path with a computer in order to minimize the requirements of the size of the control surfaces.

Mr. TALCOTT. What airplane is this?

Dr. LOW. It is a model of an airplane in one of our wind tunnels. It is a model that incorporates many of these technologies—advanced engines, a different wing shape, a wing-tip effect—we call it a winglet—which reduces the resistance of flying through the air by about 5 percent. That, by the way, could conceivably be retrofitted on existing airplanes. The airplane manufacturers are now looking at that possibility.

When you put all of these technologies together—and this will not happen for a few years yet, you can save up to 50 percent of the fuel used by today's technology airlines.

Mr. TRAXLER. How many passengers, approximately, would that plane carry, and is that a long-haul plane?

Dr. LOVELACE. That particular plane, Mr. Traxler, is really about a 180-passenger aircraft, and was really not designed specifically to meet any market or any customer, but rather as a technology demonstrator.

Mr. TALCOTT. The trouble with that airplane is that the baggage will not get there until a day after the people.

Dr. LOW. You put your finger on a problem, Mr. Talcott. You have to look at air transportation as a whole—everything from baggage handling to flight control to what is happening in the airplane itself. We are working very closely with the FAA to look at the total problem, as opposed to just the airplane itself.

RETROFITTING

Mr. TRAXLER. On the engine component improvement, last year you talked briefly with us about what was happening on retrofittings of the existing engines with noise-reduction systems. Could you take just 30 seconds and tell us what has happened in this area, or are you going to touch on it later?

Dr. LOW. I can cover it now, Mr. Traxler. As far as noise reduction itself is concerned, we developed the technology for this. We talked last year, I believe, about retrofitting existing airplanes with engines incorporating that technology. This would happen if the Federal Aviation Administration decided to pass new and stringent noise reduction rules. It is unlikely that they will do it for existing airplanes because of the very high cost of this retrofit in an already depressed industry.

However, the technology will be applied to future engines, to new production engines for new airplanes.

Dr. FLETCHER. I would like to say that Dr. Low is making a guess about the probability of FAA regulations. But FAA is still considering the problem, and has not really made a decision not to go ahead.

Mr. TRAXLER. Have they done anything about engines that are in production; that is, engines on the assembly line? Is there any requirement relative to those?

Dr. FLETCHER. There is no requirement, although some of the aircraft companies, recognizing that noise reduction is a good way to sell airplanes, are considering using this technology.

Mr. TRAXLER. Thank you.

Mr. YOUNG. Dr. Low, what is the effect on fuel consumption of this noise suppressant?

Dr. LOW. The noise suppressant system we have worked on would about hold its own in consumption, depending upon which tests are looked at. It was either a very small shade higher or a very small shade lower in fuel consumption.

PROTECTING U.S. TECHNOLOGY

Mr. TALCOTT. The technology that you developed is in the public domain; isn't it? It is available to all the other airplane manufacturing companies in the world, so we do not get much advantage from your developing the technology, whereas if the airplane companies would do it themselves, and keep patents and keep secrecy, and invest their own money, they could make more profit in technology.

"FOR EARLY DOMESTIC DISSEMINATION" POLICY

Dr. LOW. NASA is also experimenting in something new in this area. We have a program which we call FEDD—everything must

have an acronym; it stands for "for early domestic dissemination." We are putting that label on this technology, which means that for a year or two or three, this technology is available to domestic industry only, and is not to go outside the country.

Furthermore, much of the work that I have shown here of the actual carrying out of the test is done by various industries in this country under NASA guidance. That industry, by virtue of working with us on it, of course, also has a headstart on incorporating this for their own aircraft before the foreign competition can take over.

But technology is perishable. In 2 or 3 or 4 years, it would be available to everybody else. But, we would then be moving on to something else.

Mr. TALCOTT. And it is your judgment that there is not enough private capital in America interested in R. & D. to perform the things that you are doing?

Dr. LOW. I think it takes a combination of what we can do in our laboratories and with our technical expertise—which, after all, can look over the entire industry instead of only one company—and what the industry can do in producibility to bring this sort of thing about. It is the same kind of combination of work that the National Advisory Committee for Aeronautics has done with industry over the years, where we get the best of Government and the best of industry to work together to produce a whole that is greater than the sum of the parts.

ROLE OF NASA IN AERONAUTICS

Mr. YOUNG. These spinoffs that our industry gets from the space program have been very helpful, very good for our economy and for our advanced state of technology, and many, many other ways.

Now, we are talking here about developing an airplane. Could it be that you have become airplane designers as a primary function, as opposed to a basic space function? Is this what is happening, or is that what is intended to happen?

Dr. FLETCHER. The act of 1958 creating NASA assigned us the responsibility for both space and aeronautics. Years before that, the way NASA actually got started was through the NACA, the National Advisory Committee for Aeronautics. We have had this role for many years. We have thus been working with the aviation industry for a good many years, since about 1920.

The space role is a new role. The spinoffs that I was talking about are completely separate and in addition to the aeronautic spinoffs. They are in the health-related industries, in the automobile industry, in the fuel-energy industry, and in other areas. All of these are just examples of technology transfer—technology that is being transferred from both aeronautics and space research throughout the whole economy.

You probably come across this technology transfer every day, in your daily life, that is a device or product coming out of the space program. In nearly every industry that you can imagine, there is some product developed as a result of space technology—that is, technology transfer.

Aeronautics research and technology is one of our direct responsibilities.

Mr. BAUCUS. Is it not true that the thrust is changing? Looking at the deferrals of Space Shuttle, Space Telescope, et cetera, those are space programs rather than aeronautical.

Dr. FLETCHER. The thrust did change in 1958, when NASA was created, from purely aeronautical to include space.

Mr. BAUCUS. But are you not changing back again?

Dr. FLETCHER. I would say a fair amount since the decline of the Apollo program. Most of that decline that Dr. Low explained to you earlier, from the high budget down to our current budget, has been the decline in emphasis on the space program. The aeronautics program, if anything, has grown during that period of time. In those terms, the balance between space and aeronautics has shifted in favor of aeronautics.

Mr. BOLAND. Not that dramatically, though.

Dr. FLETCHER. It is most dramatically because of the cutback in the space program, rather than the increase in the aeronautics program.

Dr. LOW. The aeronautics budget is about 10 percent of the total. And with it, of course, we are developing technology, not airplanes.

DECISIONS ON FISCAL YEAR 1977 DEFERRALS

Mr. BAUCUS. Who makes those decisions like the deferrals? The President and OMB gave you limits. Did you decide to cut back there, or did OMB and the President tell you to cut back in these particular areas?

Dr. FLETCHER. We will have to take them one by one. But most of the deferrals that I mentioned were taken to the President, and he made the final decisions.

Mr. BAUCUS. Who originated them? Who said, here is where we should cut?

Dr. FLETCHER. Mr. Baucus, OMB gives us guidelines and we try to fit the budget into those guidelines. We had these programs that I said we deferred in the original guidelines. Then the President decided to cut overall Federal budget outlays by $28 billion. We were faced with a cut as our part of that $28 billion.

Then we started to negotiate back and forth. And the ones that I listed as deferrals—start of repowering the 40-by-80-foot subsonic wind tunnel, the orbiter production, the Space Telescope, and others, we felt, ought to be referred to the President. We had a discussion with the President toward the end of the fiscal year 1977 budget process, and the final result is as you see it.

Mr. BAUCUS. But were you arguing to keep these programs going and to cut some others, or were you arguing to cut these and keep some others?

Dr. FLETCHER. We were arguing to have a more reasonable portion of the cut assigned to us, instead of the very large 6-percent cut that we in effect received.

Mr. BAUCUS. I am sure you did that. Among the programs that you kept and did not keep, I am wondering which ones you argued for, as opposed to what we see presented to us here.

Dr. FLETCHER. I think you are really asking, would we trade some of these programs around? I think we would not trade any of the programs that we came out with.

Mr. BAUCUS. If I understand what you are saying, you are speaking more for the President than you are for yourself.

Dr. FLETCHER. I am presenting NASA's part of the President's budget, and I think it is a reasonable one considering the state of our economy.

Mr. TALCOTT. I think we ought to recognize that there is a lot more conglomeration here than has been presented over the years. This committee has given some direction to where we want to go. We have cut some things, and we have added some things. When we add something, that means we cut something else.

I think the President, and you and your predecessors have had a lot of guidance from the great American taxpayer. NASA has gone from $6 billion down to $3 billion. There has been a lot of pressures in that. It is not just the President. It is not just OMB. It is not just one side of this committee or the other, or the Congress. You have had a lot of input over the years, and this is a consensus, it seems to me. We have had our share in what is important and what is not important.

Dr. FLETCHER. That is quite right, Mr. Talcott. We have to take all of those factors into consideration, and we never fail to mention your feelings on some of these programs when we talk to the President about it. I think it is a consensus.

Mr. BAUCUS. What I am trying to do is try to understand how these decisions are made. As I understand you, you are making recommendations—you talked with OMB and the President and so forth, and you have been given certain guidelines. Then I guess you are saying that this is what comes of it. But I don't hear you say what you are arguing for, or what Dr. Low is arguing for, or what the President decided.

Am I asking an improper question?

Dr. FLETCHER. No, Mr. Baucus, it is not an improper question, but it is a complicated question because many negotiations go on between ourselves and OMB and the President. I think we can address one specific part of it.

For example, the energy program. I can tell you how the decision was reached. But each item has to be considered separately, on its own merits, and we do consider what the wishes of this committee are likely to be, and we have discussions with your staff and members of the committee, long before we ever complete our budget process.

Mr. BAUCUS. I would like to presently know who makes these decisions, because then I am in a better position to know what the reasons were behind those decisions, and that helps me better to decide whether we should go along with that request, and that is the reason I am asking these questions. Thank you.

SPACE TELESCOPE DEFERRAL

Mr. TRAXLER. While we are talking about establishing priorities among the various projects that the Agency is interested in, let me go for a minute to a point that Mr. Baucus is making, relating to the Space Telescope.

According to GAO, the front page of their report on the Space Telescope project reads: "NASA plans to request funds in the fiscal year 1977 budget to initiate hardware development."

Is that an accurate and fair statement? This is dated the end of 1975.

Dr. FLETCHER. Yes; that was an accurate statement. We had planned to go ahead in fiscal year 1977 with the start of the Space Telescope.

Mr. TRAXLER. I think, then, we need to question whether or not this decision was the right one.

If we postpone the development of the Space Telescope, how much more money in constant dollars, do you believe it is going to cost us?

Dr. FLETCHER. We are working on that question now, Mr. Traxler, and I don't think we have a precise answer; an approximate answer is that we don't think it will cost any more, except for escalation. You said "constant dollars." We think that we may be able to come up with some ways to actually save additional money during this 1 year hiatus. We can't guarantee that, but we are going to work very hard on the possibility of saving additional money.

The problem is that, of course, inflation goes on, and it ultimately costs you more.

Mr. TRAXLER. Thank you, Mr. Chairman.

OMB REVIEW OF NASA BUDGET

Mr. BOLAND. In line with what Mr. Baucus has developed, who in OMB handles NASA?

Do they have a team in the Office of Management and Budget that really is attuned to the programs of NASA? Is there someone who has been following it for years and knows about it—someone with expertise and knowledge in this area? Do we know that OMB does not give your budget a cursory oversight, but really gives it an in-depth look?

Dr. FLETCHER. Mr. Chairman, there is a man directly responsible for NASA in OMB by the name of Ron Konkel, and he follows NASA's programs very closely. He has been in the job for, I think, about 2 years.

Ron Konkel reports to Hugh Loweth who has NASA, plus parts of ERDA plus the National Science Foundation and many of the other agencies that you deal with. And he has had this particular assignment about 3 or 4 years. He reports, in turn, to Jim Mitchell, who is an Associate Director of OMB, who arrived there recently, and you know him from his HUD experience. He, in turn, reports to Jim Lynn, who was the Secretary of HUD.

Mr. BOLAND. OK, fine.

Mr. TRAXLER. Dr. Fletcher, is it fair to say that your conversations with the President were really an appeal from the limitations OMB placed in your budget?

Dr. FLETCHER. Mr. Traxler, I think that is a pretty good description of the process. OMB had certain desires, and we did not agree, so in a sense, the President refereed between us.

Mr. TRAXLER. You lost, but I'll bet you fought hard for the Space Telescope.

NATIONAL TRANSONIC FACILITY

Dr. LOW. Turning to aeronautical facilities, this is the National Transonic Facility.

NATIONAL TRANSONIC FACILITY

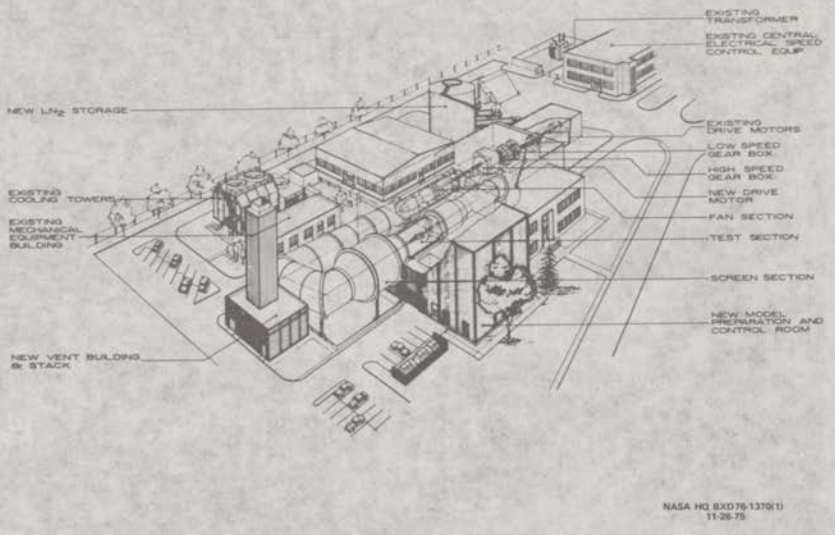


FIGURE 9

Of course, to do the work we are doing, you have to stay up to date in aeronautical facilities, and we are requesting in the fiscal year 1977 budget funds to start construction of what is called the National Transonic Facility, to be built at Langley Field.

Mr. TALCOTT. What is that? A wind tunnel?

Dr. LOW. It is a wind tunnel at Langley Field. It will be a so-called high Reynolds Number wind tunnel that will be able to test models of airplanes, but simulating larger planes.

SPACE SHUTTLE

The Space Shuttle—I am moving on now and turning to our space programs. I have three pictures of the Shuttle in various stages of assembly.

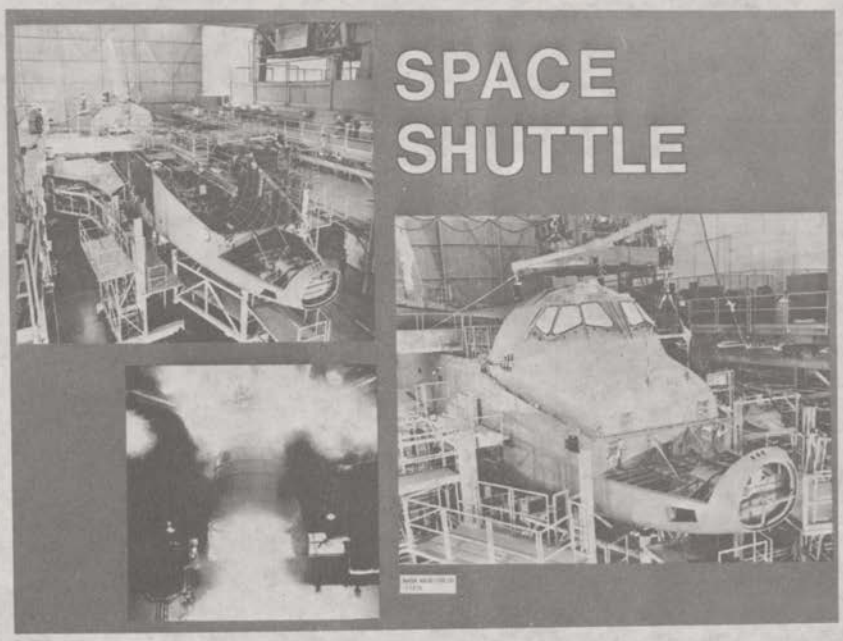


FIGURE 10

The two of the Shuttle orbiter itself were taken in Palmdale, Calif., where the vehicle is being assembled. They were taken rather recently, and they show that this first orbiter is indeed going together well. It will be rolled out as a complete airplane in September of this year.

SHUTTLE ON SCHEDULE AND WITHIN COST

Now, there is a GAO report that is coming out which contains many allegations about the Shuttle. But contrary to those allegations, the Shuttle is on schedule; it is within cost; and it will meet the performance that we have set out to accomplish.

I don't know of any other program—and I've been associated with a lot of them—that has been as well managed and is coming along as well as the Space Shuttle since we started its development in early 1972.

We predicted the cost at that time, and we are staying within those costs; we are maintaining the schedule. The only schedule adjustments were the two points we discussed with this committee in previous years, where we had to slip the schedule because of funding cuts. We are also meeting our performance requirements.

In this picture you can also see one of the Shuttle main engines in testing at the National Space Technology Laboratories in Mississippi.

That engine now has run at approximately 50-percent thrust, and it, too, is behaving well.

The Space Shuttle development is going along extremely well.

Dr. Fletcher and I were in Palmdale to observe this progress 2 weeks ago, and I would very much like to extend an invitation to the members of this committee to join us on a visit to look at it, because the Shuttle is, of course, the most important aspect of the whole NASA program because of the tremendous capabilities it will provide.

SHUTTLE APPROACH AND LANDING TESTS

Toward the end of 1977, the Space Shuttle orbiter approach and landing tests will begin. The Shuttle orbiter will be released from on top of the airplane to do its approach and landing test, gliding back to Edwards Air Force Base for its landing test.



FIGURE 11

VIKING

Let me move on, then, to Space Sciences: This is an artist's conception of what it will be like on the surface of Mars.



FIGURE 12

Around July 4 of this year, we will have the first Viking landing on Mars. Two Viking orbiters and landers are well on their way to Mars, and the first one is only 122 days away from Mars orbit as of today. Both of them are doing extremely well. If all continues to go well, the first landing should happen in July of this year.

MARINER JUPITER SATURN-URANUS

Dr. Fletcher mentioned that we could not start a new project called Mariner-Jupiter-Uranus. On the other hand, we do have under development the two Mariner-Jupiter-Saturn missions—two spacecraft to be launched to Jupiter and Saturn. They will be launched from Earth in 1977 rounding Jupiter in 1979, and flying past Saturn in 1980 and 1981, respectively, for a closeup look with scientific instruments at those planets.

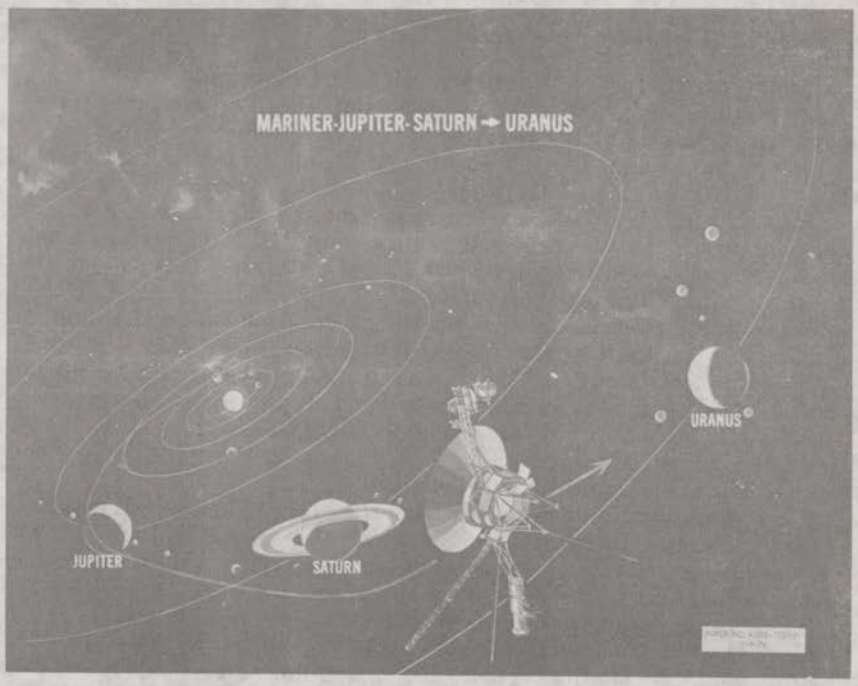


FIGURE 13

We are now examining whether the second of those two spacecraft could be sent on from Saturn using a "billiard ball" effect, if you will, of picking up velocity around Saturn and going on to Uranus, arriving there in 1985, to give us the first closeup look at the distant planet.

For a very little investment, we hope we will be able to send the second spacecraft on out to Uranus. The decisions will be made in subsequent years as to whether we, indeed, want to do and can do that.

FUTURE PROGRAM POTENTIAL

Mr. ROUSH. Dr. Low, if you just let your people go with their imaginations—the ones who are the dreamers or visionaries, they would have you on a course that would take you much beyond your current program, wouldn't they?

Dr. LOW. Very much so, Mr. Chairman.

Mr. ROUSH. What are some of the most far out things some of them might be suggesting that you do?

It seems to me our record is not complete if we do not at least, even recognizing the financial constraints and all that we operate under, if we did not do a little dreaming for the record. I wanted to ask that question a moment ago.

Dr. FLETCHER. I would like to try that, Mr. Chairman.

It's hard to say what is the most far out, because there are a number of programs that have a very high popular interest.

One of the highest is the idea of establishing a space colony out in space which would initially produce power for use of people here on Earth. It would be in orbit not too far from the Earth, and it would collect power from the Sun and beam it down to Earth. This colony would be a very small group of people, but ultimately they would like to move to produce a colony of—I think the initial colony is 10,000 people—in an orbit around the Earth at a location called Lagrangian Liberation–5, standing for Lagrangian stable point No. 5.

It is a place about 250,000 miles away from the Earth. The colony would be self-sufficient, once it was started. It would use energy from the Sun. There's all kinds of energy available, once you get out away from the Earth. Moreover, it is free; it is unlimited; and it is without pollution if you could just collect it.

They would get their minerals from the Moon. They would actually mine the Moon. It's much easier to get minerals from the Moon because of the low gravity, and because the Moon has no atmosphere it is possible to project materials from the Moon out to the space colony.

The space colony would, of course, be a new experiment in social living. It would not be overly costly, if the country were prosperous, but it would be another Apollo-like program, and so we would not propose anything like that now. Nevertheless, the concept appears to be very popular with a large section of our population, just the idea that a portion of our people can still colonize distant places, much the same as we used to in the early beginnings of this country.

Mr. TALCOTT. Would they have to carry food?

Dr. FLETCHER. They would grow their own food, of course, in this colony by using the energy from the Sun and the nutrients, that is the minerals, from the Moon.

Mr. BAUCUS. What would be the area for 10,000?

Dr. FLETCHER. I don't happen to remember the total extent. It would be on the order of 200 meters across and 1 kilometer long.

Mr. YARDLEY. The biggest colony would be about 6 kilometers in diameter and 32 kilometers long.

Mr. BAUCUS. Who conceived this?

Mr. YARDLEY. Dr. O'Neill, a professor at Princeton.

Mr. TRAXLER. Dr. Fletcher, if the scientific theory on which this is based is all present, and the technology is present, then it's a matter of fabrication and design?

Dr. FLETCHER. Yes, I think there is nothing at all that is technically unfeasible about this program. It is a question of dollars, and right now it doesn't seem like the time to start spending the dollars.

Mr. TRAXLER. We appreciate those limitations, but pursue the microwave aspects of this concept for a minute. Its author sees tremendous quantities of energy coming to the Earth in the microwave theory. Do you think this is a practical way of deriving a new energy source?

Dr. FLETCHER. Mr. Traxler, I actually think it is a good way to do it.

We have already, for example, transmitted on earth by microwaves something on the order of 200 kilowatts of energy—but just to give

you a feeling for how many that is, that would be about the equivalent of 200 flat irons, which isn't very much, but it is a start.

That was out on the Mojave Desert.

To do it in terms of the size of the city of New York would require a much larger antenna, but certainly it is technically feasible. There is nothing at all impractical about it.

Mr. TRAXLER. One of the interesting things about this concept is that the cost could be returned to the Government through the sale of the energy.

Dr. FLETCHER. In the long run, it certainly could.

The problem is the initial investment.

But according to the calculations, now—I think you cannot make calculations extending that far out. The figures are always a little questionable, but according to the calculations, it would eventually give a good return on the investment.

Mr. ROUSH. I realize that the chairman intended to hurry here, and I wanted to ask these questions, and, being the chairman, I guess I can ask them.

AUTOMATED PLANETARY EXPLORATION

Mr. TALCOTT. Could I ask something along this line?

In distance, how far would you go out in the universe? What are your projections if we are willing to do that sort of thing?

Dr. FLETCHER. For a colony, we would not go much beyond——

Mr. TALCOTT. I do not mean colony; I mean unmanned exploration.

Dr. FLETCHER. For unmanned spacecraft, we will go out to the end of the solar system. The last planet in the solar system would be Pluto.

You may remember that about 1971, we had an Outer Planets program planned—grand tour plan for visiting each of the planets in turn, out to Pluto, because they would be alined properly. That is, you could start with Jupiter, Saturn, Uranus, Neptune, and then Pluto. We were not able to proceed with that plan.

Tha opportunity only comes around once every 140 years, and we passed it. So now we will have to take the planets one by one. That is why Uranus is so interesting. We had an opportunity that came only once every 14 years to go to Uranus.

Mr. TALCOTT. I think once some of us on the committee did not realize that it only came up once every 140 years. We might have been more interested in these launch windows that you have talked about.

Mr. ROUSH. I think they testified to that.

Dr. FLETCHER. Yes, Mr. Chairman.

Mr. TALCOTT. You told us it was very important that we do it in 1978, but I do not remember you making the point to us that if we do not do it now, we would have to wait until 2088.

Dr. FLETCHER. By way of self-criticism, I think we probably should have given you a little longer time to consider it. If we had told you a year before you had make the decision, we might have been a little further ahead.

Mr. TALCOTT. Do you have anything else like that?

I wonder if we could project those a little bit further in advance, so we do not get trapped.

Dr. FLETCHER. We would be glad to furnish for the record some of these opportunities in the future. Opportunities for the closer planets,

such as Venus and Mars, occur more often—Mars and Venus every 2 years; Venus every 18 months, or something of that sort. The farther-out planets occur less frequently.

We would be glad to furnish maybe a list of the opportunities that are interesting and what years they occur in.

[The information follows:]

In principle, there are relatively frequent opportunities to send spacecraft to the various planets: Opportunities to send spacecraft to Mercury recur every few months; opportunities to send spacecraft to Mars recur every 26 months; and opportunities to send spacecraft to the other planets recur somewhere between these two extremes. If a hypothetical launch vehicle of ultra-high performance and low cost were available, the uniqueness of launch opportunities would not be a major concern. In fact, because of launch vehicle limitations, it is virtually impossible to send spacecraft directly to Mercury or to the planets beyond Jupiter.

An ingenious technique has been perfected by NASA's Jet Propulsion Laboratory that utilizes a flyby of an intermediate planet to impart the additional energy that is required to reach a more distant planet: For example, a Venus flyby can be used to send a spacecraft to Mercury as was the case with the 1973 Mariner Venus/Mercury mission or a Jupiter flyby can be used to send a spacecraft to Saturn and beyond as is the case with Pioneer 11. However, this technique is not without its drawbacks: The target planet and all the intermediate planets must be properly alined—a relatively infrequent occurrence. As an example, from 1977 to 1979, the planets Earth, Jupiter, Saturn, Uranus, and Neptune will be so uniquely alined that it would have been possible for a single spacecraft to visit four outer planets—this is the so-called "grand tour." The alinement could also have been used to send a spacecraft from Earth to Jupiter, Saturn, and then on to Pluto. This unique alinement last occurred during the Presidency of Thomas Jefferson and will next occur in 2157.

In addition to these planetary opportunities that are unique because of planetary alinement, there are opportunities to investigate comets and asteroids that are unique because the bodies infrequently come into nearby regions of the solar system.

Barring radical improvements in propulsion technology, the following launch opportunities are unique in the sense that they recur very infrequently.

There is a very good opportunity in 1977 to send a Mariner-class from Earth to Jupiter, Saturn, and on to Pluto. A more modest mission—the Mariner Jupiter/Saturn mission—was approved by the Congress in fiscal year 1972. The two Mariner spacecraft to be launched in 1977 will reach Jupiter approximately 2 years after launch and will reach Saturn in an additional 1½ to 2 years. If the first spacecraft achieves its objectives and if the second spacecraft is operating properly when it reaches Saturn, the latter's encounter at Saturn can be modified so that the spacecraft proceeds to Uranus. The next opportunity to reach Saturn via Jupiter will be in 1998; the next opportunity to reach Uranus via both Jupiter and Saturn will be 2117.

There is a very good opportunity in 1979 to send a Mariner-class spacecraft to Uranus via Jupiter. This opportunity was the basis of the Mariner Jupiter/Uranus mission (MJU'79) that NASA unfortunately had to forego. The flight time to Uranus for the MJU spacecraft would have been approximately 5½ years as opposed to the 8 years that would be required for the MJS spacecraft to reach Uranus; therefore, the chance of obtaining data at Uranus would have been greater for MJU than it is for MJS. An additional advantage of the MJU mission is that its payload would have been optimized for gathering science at Uranus. The next opportunity to reach Uranus via Jupiter will be 1994. However, the pole-on Uranus configuration that is so scientifically unique will not recur until 2022.

There are also several opportunities during the mid-1980's to send spacecraft to Uranus via Saturn; however, the energy requirements are higher. These opportunities will not recur until 2028.

There is an opportunity in 1993 to send a spacecraft to Neptune via Jupiter. Similarly, there are opportunities in 1990 and 2002 to send spacecraft to Pluto via Jupiter.

Halley's Comet, the most spectacular and famous of the comets, will return in 1985 after an absence of 76 years. It will be possible to launch a spacecraft in 1985 that would encounter Halley and make detailed observations of its composition and structure. The next opportunity to visit Halley will be in 2061.

Finally, an asteroid called 1976 AA has been discovered in the vicinity of the Earth. This asteroid will again be close to the Earth in 1996, and it should be possible for a spacecraft to rendezous with it in order to make detailed observations and, possibly, to return a sample to Earth.

The alinement of the planets is, more often than not, the reason that an opportunity is unique; however, it is also possible for technological advances and for certain space hardware to provide unique opportunities. If nuclear electric propulsion were now available, it would have been possible for a spacecraft to rendezvous with Halley's Comet and to make numerous closeup observations over an extended period of time; this would have been far superior to the fast flyby mission that we are now considering. In a sense, the lack of technology has precluded the opportunity to take full advantage of a relatively unique occurrence.

POTENTIAL INTERNATIONAL COOPERATION

Mr. ROUSH. My next question was just that: What opportunities exist for space exploration or research which we cannot take advantage of because of the financial constraints? If you could supply that for the record, I think we would find it useful.

Has any thought been given to perhaps, well, say through the United Nations or through some other means, of establishing a consortium of nations who might share the cost of certain space research, which maybe one nation would find too expensive but the results of which might be very useful to the scientific community and, eventually, to the people of the Earth?

Dr. FLETCHER. Mr. Chairman, the notion of a consortium perhaps ought to be explored further. There is a consortium in Europe, called the European Space Agency, ESA for short, and we do share programs with this Agency.

They in fact are building the Spacelab, which will be a reusable, versatile space laboratory carried in the cargo bay of the Shuttle that Dr. Low has just described to you. ESA has estimated that it will spend approximately $515 million to develop the Spacelab. They also share in many other programs.

But what you are talking about is a worldwide consortium, probably involving both the Soviets and Europe. These far-out programs, for example the L–5 type programs, I think, ought to be international programs. We ought to share according to our individual financial resources.

POSSIBILITIES OF EXTRATERRESTRIAL LIFE

Mr. ROUSH. I have always thought that if there is a threat from outer space, that it might do a great deal toward bringing the nations of this world together. Not that it would ever happen; but if it should, probably this would be an immediate result.

What are you doing, if anything, to determine the possibility of life on other planets outside of our own universe?

Now, I understand that Viking's landing on Mars might make some contribution in that regard. Are you doing anything else?

Dr. FLETCHER. Mr. Chairman, the way it looks now is that in our solar system there are two or three planets or bodies that are most likely to have life present.

Mars is one of them, and that is what Dr. Low was talking about. We are going to see, in those two places where we are going to land, if there are any signs of life.

Moving out from there, another likely possibility is on one of the moons of Saturn, called Titan. This moon is a very large moon. It is

about like our Earth, and it has an atmosphere something like Earth's, but we do not know much more about it. It has temperatures that are right. It has kind of a greenhouse effect that keeps things warm underneath. So that would be the next likely place to look for life.

A third possibility—and the scientists are arguing about this, and maybe Dr. Hinners can correct me if I am not up to date on it—is in the upper atmosphere of the planet Jupiter. The temperatures are right there, and the right kinds of nutrients are there for certain kinds of life. It is very turbulent, though; it is always bubbling over in Jupiter. Whether life can actually survive in that turbulent environment is hard to say.

But those are the most likely places in the solar system. We might get surprises, by the way, but that is what scientists are betting on.

Mr. BAUCUS. What about beyond?

Dr. FLETCHER. Now, if you go beyond the solar system, here is the astounding fact, Mr. Baucus—and I really believe this—it is very likely that there are intelligent beings outside of our solar system. The frustrating thing is, we do not know of any way to go out and visit them. We do not have the technology to actually leave our solar system. The next star is too far away.

The scientific community, I would say, is almost unanimous—and Dr. Hinners will correct me if I am too far wrong in this—believing that there are intelligent beings out there.

Mr. BAUCUS. I tend to agree with you. But how far away is the next solar system?

Dr. FLETCHER. The nearest one is 4½ light-years away, and we cannot even get there. But the chances that we would have intelligent life like ourselves on that particular star are not very great. The chances are you would have to go out more like 1,000 light-years.

The only thing that we know how to do—and it is a little strange, but that is all we can think of—is to start broadcasting to them and to listen to their own broadcasts. If they are as far advanced as we are, they are probably just as anxious to communicate as we are.

Mr. BAUCUS. Would the Space Telescope help here or not?

Dr. FLETCHER. The Space Telescope could help some, in that we could tell which of the nearby stars have planets. It may help in other ways, but that is the only way I can think of at the moment.

Dr. HINNERS. The main one is the need to make a first determination as to whether or not these nearby stars do have solar systems, planetary bodies around them.

Mr. BAUCUS. But how do we listen?

Dr. FLETCHER. The only way to listen that we have come up with so far is to set up a large array, if you like—a large number of radio listening stations. It would take a fairly big investment; and then, one by one, listen to each one of the stars in our neighborhood.

When I say "listen," you would listen for dots and dashes, that is to say a coded signal, because chances are that is the way they would communicate. That is the way we communicate with our telemetry to our own spacecraft. And you would look for regularities of that sort.

By the way, we found something akin to these, but it turns out to be just regularities in the motions of stars themselves and not intelligent signals.

We would look at these regularities and decide if they added up to something that we could decode. You would put your best decoding

people on it. But once you got those regularities, you would know you had something very interesting.

You would simply listen, month after month, year after year, with these telescopes. They can be doing other things at the same time, things like radio astronomy, but mostly they would be seeking for signs of intelligent life outside of our own solar system.

Mr. ROUSH. As an observation, here a few years ago, when I was on the House Committee on Science and Astronautics, I was pestering Chairman Miller for a chance to hold hearings on UFO's, and he just always turned away and in a very brusque manner said, no, he did not want any part of it. He thought it would just be a show.

He went to England, and he visited the telescope there, and Sir Bernard Lovell. Just about that time, Dr. Lovell had received some communications that seemed to have some pattern to them. So Chairman Miller came back and gave permission that—I had to change the name—a symposium on UFO's, and we had a very, very pleasant day and successful symposium on UFO's, which I would commend to you for reading.

There is another aspect to this. In talking with one of your scientists at Ames, he pointed out that if we could communicate, that one of the objectives, then, would be perhaps to measure or project the expected life of this planet, of the civilization on this planet. Because by measuring them there, we would know what to expect here, which I thought was rather interesting.

Now, do you have scientists that have presented to you plans that you have rejected to do these things that you mentioned?

Dr. FLETCHER. Mr. Chairman, we have a very-low-funded program.

Mr. ROUSH. I know that. But I just wonder if people are asking you to do things that you have to say "No" to?

Dr. FLETCHER. Yes; we do. The center of this activity is at Ames, but we have also proposals from companies and from other centers to do some of the technology that would be required to listen for these other intelligent beings.

I would like to comment on your first statement, because I sincerely believe this: I think if we could hear and listen to these other intelligent beings and they had survived some of the problems that we are going through now, you could not put a cost/benefit on that. That would be a new dimension for us. It would change our whole manner of thinking. So the investment would be large, but the rewards would be immeasurable, because they apparently have survived, or would have survived, a lot of the crises that we are now going through, and we could learn from them.

Mr. MCDADE. Would you yield, Eddie?

Mr. ROUSH. Yes.

Mr. MCDADE. Dr. Fletcher, what are the indices that lead you to conclude that there is life in other solar systems?

Dr. FLETCHER. I do not pretend to be an expert in this field. It is a brandnew field called exobiology. It means outerspace biology. But they tell me the reasons go something like this:

There are about 100 billion suns like ours in the Milky Way in our own galaxy, 100 billion suns. Most of those, maybe 60 percent of those suns, are about like our Sun: the same size, more or less, with the same process of stellar evolution.

Now, we do not know what fraction of those have planets, but let us say some fraction have planets like ours. Some of that 100 billion are going to have planets that have exactly the same conditions for life that we have.

Now, here is where you get into a little discussion depending upon whether you are a scientist or whether you are a religious person, or both. But whatever the case, if those conditions are right for life, some of them are going to have life, whether it is planted there or whether it evolved in a natural process.

But because there are these planets that are similar to our own, and because there are a very large number of them, the chances are extremely high that there is, or there has developed intelligent life like our own.

Now, Noel, I do not want to exaggerate this. You have been closer to the exobiologists than I have. Would you like to add to what I have?

Dr. HINNERS. No. The estimates—and that is all there really are—are that there are maybe 200,000, 400,000, 500,000 situations similar to Earth where life might have evolved.

Mr. ROUSH. You are talking about just our own galaxy?

Dr. FLETCHER. Just our own galaxy, and that is all I really want to work on for the moment.

Mr. ROUSH. What you have said is what Dr. Carl Sagan says; is that not correct?

He says, mathematically, it just has to be.

Dr. FLETCHER. Dr. Low reminded me of one other thing. That is that the exact same chemistry exists in these suns as we have on our own Sun, and the planets are likely to have the same kind of chemistry as our own. There is some evidence of that.

Strange as it may seem, a lot of these objects coming from space, meteorites, for example, have organic molecules, things that could have been part of life, or could have been the building blocks of life. And if you look out with telescopes into the Milky Way, you can see evidence for the same kinds of organic molecules in the Milky Way.

All of these are little clues. You cannot really prove it, but they lend credence to the fact that there is intelligent life out there.

Mr. YOUNG. I understand Dr. Fletcher does not want to go beyond our own galaxy. But just for the benefit of those of us who are interested but do not have the knowledge, in the known universe, what part does our galaxy play?

You say we have 100 billion suns. We are one of the 100 billion suns in our galaxy. What is our galaxy? Are we one of another 100 billion galaxies?

Dr. FLETCHER. I would say that. I would say 10 billion anyway, and maybe 100 billion.

Dr. HINNERS. About 100 billion galaxies.

Dr. FLETCHER. A lot of those are an awfully long way away, and I think we ought to focus on our own for the moment.

Mr. BAUCUS. Mr. Chairman?

Mr. ROUSH. Mr. Baucus.

Mr. BAUCUS. Staying within our galaxy, I am wondering how much more technology we on earth or some other hypothetical earth might have to have in order to communicate; how much more power do you need to communicate this Morse code or whatever it is going to be? And

how advanced does some other society have to be, compared with ours presently?

Dr. FLETCHER. Mr. Baucus, I have to separate that into two parts. If we knew somebody was trying to communicate——

Mr. BAUCUS. Let us assume somebody is.

Dr. FLETCHER. Then, even with our current telescopes, we could listen to that communication with the very large antenna down in Arecibo, which is sponsored by the National Science Foundation, and also by ourselves. That could receive a signal if the sender had a sufficiently powerful transmitter, but they would have to be looking right at us.

Now, if we want to pick up just signals of somebody that is searching around and does not know we are here, it would take not a large amount of power, but it would take a very large antenna to receive that much smaller signal.

Now, how advanced would they have to be? They would have to be at least as advanced as we are, and we have only known how to do this for maybe 30 years. They would have to be at least 30 years into this high technology era that we are in.

Mr. BAUCUS. I am assuming that they have reached the same conclusions that we have reached. That is, that while they are out there somewhere, there is probably life somewhere else, and we cannot get there; maybe we can listen and communicate.

So, I am just wondering how much more it is going to take to listen, or for some hypothetical other earth to transmit. And once we answer that question, if we do not hear anything, maybe there is nothing out there, or else they are much further behind us.

Dr. FLETCHER. Mr. Baucus, I think you have made a very good analysis of this. Indeed, that is pretty close to the way the scientists feel about it.

They say, if we do spend some money—and they have estimates of about how much it would cost—it would not be an Apollo program, but it would be a sizable venture, something like the Space Shuttle. If we invested that money and we did listen for a sufficiently long time and in spite of this we found no one, that too would have tremendous philosophical implications. We would be all alone in our own galaxy.

Mr. ROUSH. The fact is that the radio telescope antenna in Arecibo and the Mills-Cross radio telescope near Canberra, they are receiving signals that were emitted—I do not know whether to say billions of light years ago or away.

Is that not correct?

Dr. FLETCHER. Yes. In fact a number of scientists feel that our space instruments today are detecting remnant echos of the Big Bang—the 3 degree radiation as the scientists call it!

Mr. TALCOTT. Are we sending signals to somebody, or trying to send signals?

Dr. FLETCHER. Mr. Talcott, we have actually sent signals from Arecibo. I have forgotten which exact stars we sent them towards.

Mr. TALCOTT. To one out of 400,000?

Dr. FLETCHER. Yes. We picked a likely target, and we beamed an intelligent signal to that star.

Mr. ROUSH. I think Dr. Low should proceed. Chairman Boland will be amazed at how far we have gotten.

SOLAR MAXIMUM MISSION

Dr. Low. Could I cap this discussion, Mr. Chairman, with a quotation from Norman Cousins, which he made before another committee of the House. He said, "When there are no limits on the laws of chance, the possible becomes the inevitable."

Since the distances are so vast, and since time is so long, there are really no limits on the probability of finding life elsewhere. So the possible becomes the inevitable.

Let me get to a planet much closer to home, or a star much closer to home, our own sun.

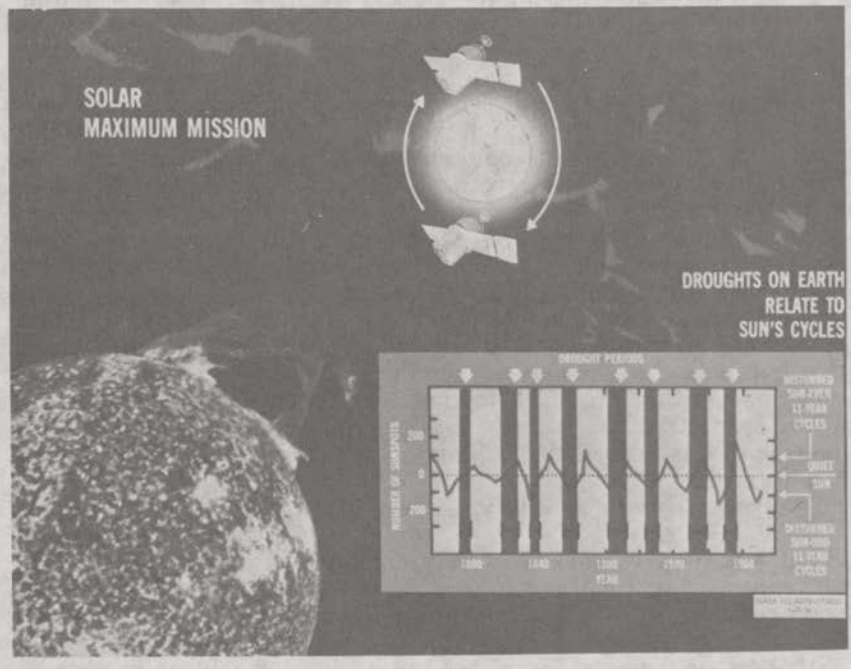


FIGURE 14

We are requesting funds in fiscal year 1977 to start what is called the Solar Maximum Mission, which will be an earth satellite looking at our Sun, its purpose is to take a close look at our own star during a period of high solar activity at the end of this decade.

IMPORTANCE OF SOLAR MAXIMUM MISSION

Now, why is this important? We have some very good empirical evidence that our climate on earth—the droughts, the dust storms, the colder periods—are directly related to what happens in the Sun. To show this I have an empirical plot here of the sunspot cycle; the number of sunspots, counted year after year, going back to the year 1800.

Every 11 years, there is a sunspot peak. We have divided these in this analysis according to odd-year cycles and even-year cycles.

What has become apparent is that, as one passed from an odd-year cycle to an even-year cycle, through a minimum every 22 years, there happened to be a drought in the Plains States region of the United States.

This is totally empirical correlation. We do not understand it yet. We do not even know whether or not it is a coincidence. But it is unlikely to have happened coincidentally so many times.

I presented the same chart to another committee late in January in our authorization hearings and said that we do not know what is going to happen this year, and we are not going to predict any droughts, but we are approaching another one of these minimums in the sunspot cycle coming up either this year or next year.

That was on January 26. On February 3, I looked at the front page of the Washington Post, and the headline was "Dustbowl Peril Faces Wheat Areas in the Plains States."

There are certainly indicators that we are approaching one of these drought time periods. We do not know this for sure yet; but we particularly do not know why it is happening. Therefore, it becomes terribly important to understand the Sun.

Mr. BAUCUS. What are some very remote possible explanations?

Dr. LOW. I will see whether Dr. Fletcher, Dr. Hinners or Mr. Mathews is willing to speculate here.

Dr. FLETCHER. I will try. Actually, during the sunspot cycles, as you know, there is a lot of radiation coming off from the Sun. It disturbs radios and radio transmissions and things of that sort on Earth. This radiation is, among other things, a large number of particles, mostly electrons and protons, that spin off when the sunspots produce flares, sometimes called solar flares.

Now, some of these particles hit the Earth. Most of them get absorbed in the upper atmosphere, and here is where we are stymied. Most of the weather, we have always assumed, is caused by the Sun hitting the tropical zone and causing hurricanes and, in general, wind circulations in the Northern and Southern Hemisphere. But it is possible there is an interaction between what goes on in the stratosphere and what happens down below.

We know that these particles first of all affect the ionosphere, which is way high and that is what affects radio transmissions. We also suspect strongly that they affect the ozone layers in the stratosphere.

Until recently, people have not thought very much about the interaction of the stratosphere that is high up, and the lower atmosphere where most of the weather is. There may be some cross-coupling between these layers of our atmosphere that just tips the scales in terms of a climate change.

However, I am a little out of my element. Noel, you are the expert.

Dr. HINNERS. I would only add one thing to that.

Until a few years ago, this was not taken seriously. It smacks too much of astrology. People are convinced now that there is a triggering-type mechanism induced by this solar activity.

What we have now seen from spacecraft is that with these alternate odd and even cycles, about 20 percent more of the solar particles get into the Earth's protective envelope during one part of that cycle than during the other part.

But how these particles actually get down and trigger a reaction is not known. Speculation is that the ionization caused by these particles may have some effect on the dust nuclei on which vapors eventually condense to make rain. But it is pure speculation, and we are really now just to the point where we are taking seriously the exam-

ination of this as a scientific question. We are really trying to understand cause and effect here for the first time.

Mr. BAUCUS. Thank you.

Dr. LOW. With these long-term climate changes on the Earth, it becomes terribly important to understand the Sun better. That is why we are proposing as one of our new starts the Solar Maximum Mission.

WEATHER, CLIMATE, AND THE STRATOSPHERE

Let me move on to another subject; it concerns the weather, climate, and the stratosphere of our planet.

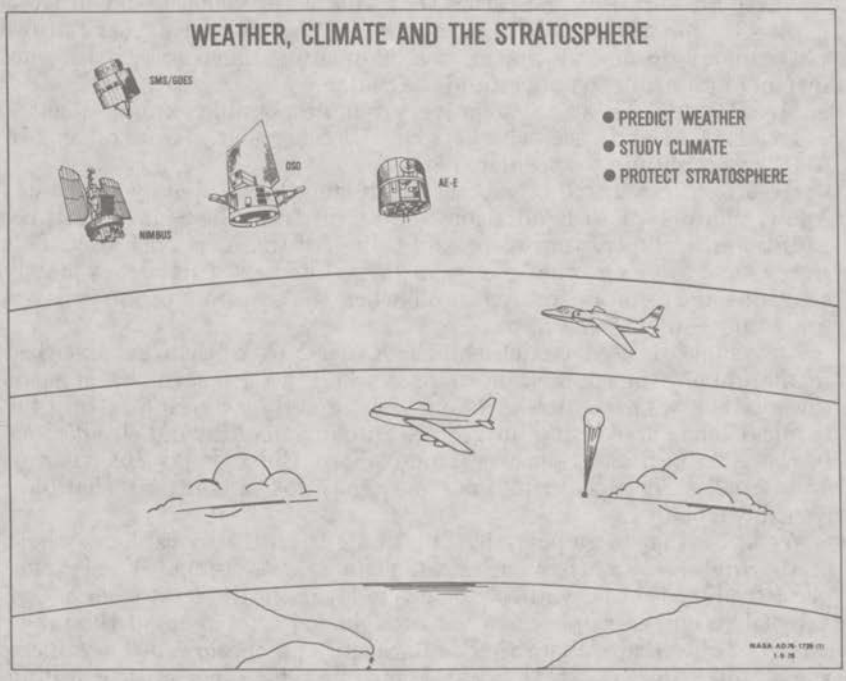


FIGURE 15

The stratosphere: What are we doing to the stratosphere from down here on the Earth? We believe that high-flying airplanes in large numbers could start disturbing the stratosphere. We are very much concerned that the freons, the chlorofluoromethanes, which are the propellants in all of the widely used spray cans, could drift up into the upper atmosphere and start destroying the ozone layer.

If that happens, if that is really true—and there are many indications that it is—that could have a very serious effect on what is happening down here on the surface of the Earth. So, we are undertaking a very major research effort using satellites, airplanes, balloons, and laboratory studies to try to understand, between now and early next year, what we are really doing and how we are affecting the stratosphere by what we are doing down here on the Earth.

APPLICATIONS—MAGSAT

Let me now turn to Applications.

Magsat. This is a small Explorer satellite that will be able to measure in detail the Earth's magnetic field.

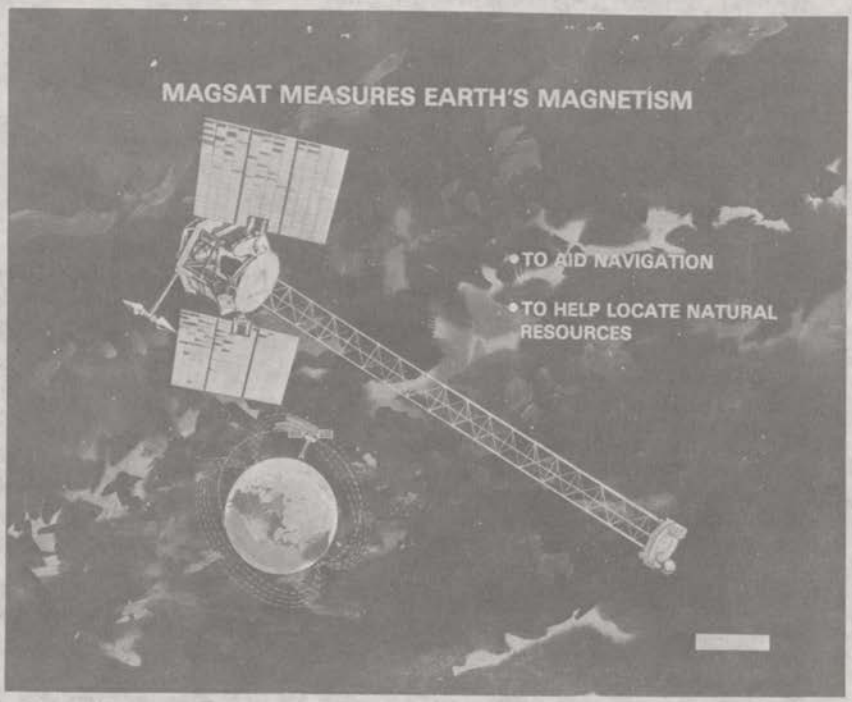


FIGURE 16

First of all, navigation charts must be updated which can now be done from satellite measurements.

Second, to help find on a global basis what are called magnetic anomalies. These are magnetic differences in the structure of the Earth which could be indications of geologic differences and which could in turn indicate the location of minerals. By flying a satellite like Magsat, by studying the magnetic field of the Earth, we have some indications that we will be able to help locate natural resources.

Mr. BAUCUS. Mr. Chairman, at that point, who do you tell, Gulf or Mobil?

Dr. FLETCHER. Mr. Chairman, we will tell the U.S. Geological Survey, and they will decide who to give the information to.

Mr. BAUCUS. How does that work? Do you know?

Dr. FLETCHER. The USGS publishes reports on the anomalies. As you probably know, they publish complete geological reports regularly. They will then publish a complete magnetic map of the globe, which will be available to everybody. Then it is up to the individual companies to decide whether this anomaly is important, along with whatever else they happen to know.

Dr. LOW. It is an indication of where to go to explore. It does not say this is where it is.

Mr. TALCOTT. We have other maps that have been helpful to all kinds of business and industrial enterprises.

Dr. Low. Yes. In fact, I will comment a moment on the LANDSAT, the agricultural maps.

Mr. TALCOTT. SEASAT could tell people where huge schools of fish are, and we will just let them all go out and chase the fish, I guess.

Dr. Low. I think you are putting your finger on a very important problem, and we will discuss it in terms of LANDSAT in a moment. That is why in agricultural products it is particularly important.

LAGEOS

Let me go to the next chart, which is LAGEOS.

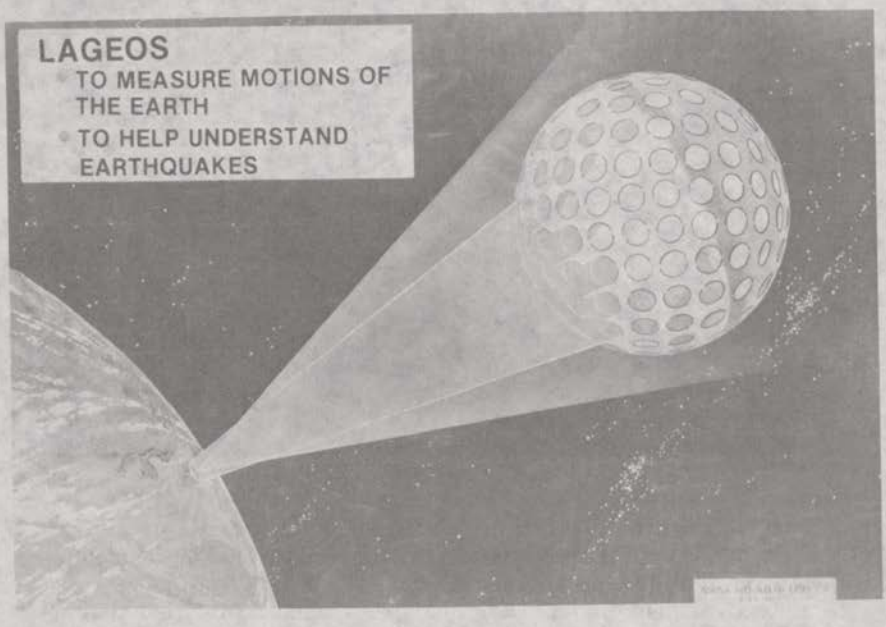


FIGURE 17

LAGEOS is a geodetic satellite which will be launched in April of this year. It is a big sphere which has small reflectors on it which will reflect back to the Earth laser signals sent to this satellite. From that reflection, we will be able to predict very precisely the locations of points on the Earth and how these points move over time as the plates, the so-called tectonic plates on which the continents sit, move about. In other words, with LAGEOS we will measure the motion of the continents and, ultimately, will begin to understand earthquakes.

LANDSAT

Let me turn now to our LANDSAT project.

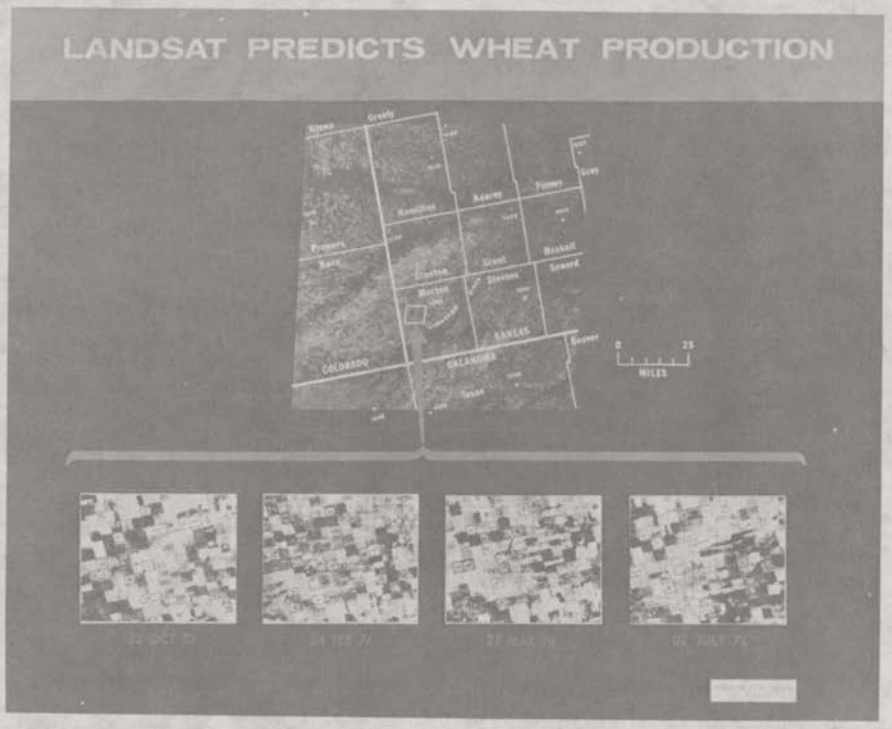


FIGURE 18

We mentioned last year that with LANDSAT we have an experimental program in conjunction with the Department of Agriculture and the Weather Service to predict wheat production. Specifically, what we do is use a satellite to measure wheat acreage and to determine the bushels per acre as much in advance as possible. This will give us, first of all, North America, and then ultimately worldwide, predictions of wheat production.

The experiment has now run for about a year. All of the initial indications are that we will, indeed, be able to do what we set out to do: Use a satellite to measure agricultural production.

Here it becomes particularly important that the information gathered does not go to individuals but is made available to all of those who can benefit from it at the same time. Therefore, it is fed directly into the Department of Agriculture, and they have formal procedures to allow this information to come out only at certain times and then equally to all parties.

Mr. TALCOTT. So we tell all the farmers in Montana that we have this good information?

Dr. Low. They find out at the same time everybody else does, through the Agriculture Department and its normal methods.

SEASAT

Let me move on, then, to SEASAT, which you also mentioned, Mr. Talcott.



FIGURE 19

This is a new satellite that will fly in 1978 and that will extend the same techniques that we are using in LANDSAT to the oceans—namely, observing the Earth from orbit in various parts of the color spectrum. SEASAT will be able to measure currents and tides, sea state, surface winds, surface temperature, ice conditions, coastal regions, and atmospheric water content.

Some economic analyses conducted so far have indicated that one ought to be able to save, for the shipping industry and others on the order of $350 million a year from this type of information.

Mr. TALCOTT. Where does this picture portray?

Dr. LOW. This picture is taken with the same kind of instrumentation from Skylab. It is the Barrier Islands in the Caribbean. You can see from it the shallow waters.

We have run some experiments now using LANDSAT that show that you can measure the shallow ocean depths and prepare new maps to keep tankers from running aground. This is an ongoing experiment using LANDSAT.

Mr. TALCOTT. Do we let all of the sea companies know about this information? We do not intend to keep that secret; do we?

Dr. LOW. No, that will be generally available information. We will update maps through outfits like NOAA, the National Oceanic and Atmospheric Administration.

We are using wherever possible the existing Federal agencies and establishments that have been developed over many years, such as the U.S. Geological Survey, the Department of Agriculture, and the Na-

tional Oceanic and Atmospheric Administration, as the distribution center through which to send this space-derived information.

Mr. TALCOTT. But you do not try to keep it from Gulf or Exxon or anybody like that; do you?

Dr. LOW. No; they get it through the normal outlets.

POTENTIAL AUTO FUEL SAVINGS

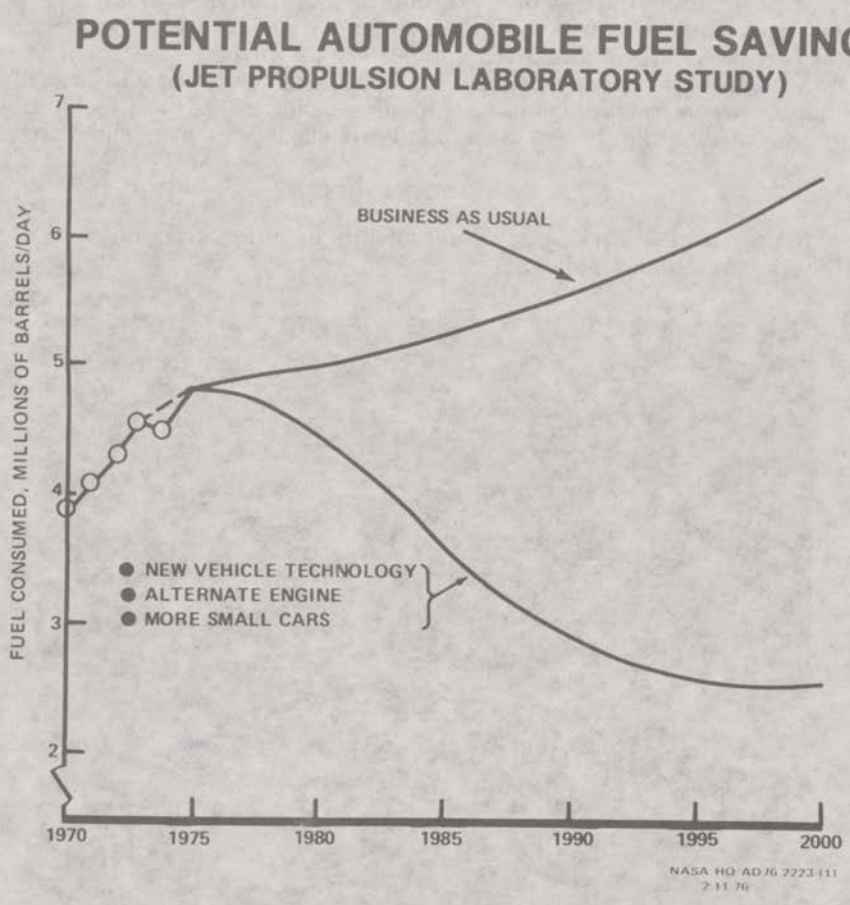


FIGURE 20

Now, let me turn to a brief discussion of some of the spin-offs, if you will, from the NASA programs.

I have taken here a curve out of a report prepared by the Jet Propulsion Laboratory with funding, not from NASA, but from the Ford Motor Co., but using people that have worked on the space program to do the report. At the Jet Propulsion Laboratory, they have done one of the finest studies of the future of the automobile. Should there be ultimate powerplants? What kind of gains can be had in automobiles by applying new technologies?

I have one curve here which I call "business as usual." This would be fuel consumption by automobiles in the United States in barrels per day if only the normal kind of technology or technological changes were made over the years. By applying things like the composites that we talked about earlier to make lighter cars; by ultimately, in 10 years or so, coming up with an ultimate powerplant that might be a turbine, or it might be an engine called a Sterling engine; and by changing the mix of cars, going to more and more smaller cars, one could move this fuel consumption curve down by a factor of about 60 percent if all of these technologies are applied.

Now, what Jet Propulsion Laboratory has done is to provide a road map on where the automobile companies should focus their technical resources in order to get these kinds of efficiencies over the years.

GAS TURBINE ENGINE

NASA is also working with automobile manufacturers on some of these advanced powerplants.



FIGURE 21

In this case, I have shown a picture of a gas turbine engine installed in a car in a joint program with the Chrysler Motor Co. This is being done in our Lewis Laboratory. It is funded in part by the Energy Research and Development Administration.

WINDMILL ENERGY

Other applications: Also, we have built a windmill with ERDA in Sandusky, Ohio. It generates 100 kilowatts of electric power.



FIGURE 22

It could be scaled up, and we are working with ERDA on scale-ups into a 1.5-megawatt capacity windmill.

Mr. BAUCUS. How do you get the right number of cycles per second with wind velocity changing?

Dr. Low. The propeller blade is feathered, just like the blade on an airplane, so you run the windmill for maximum efficiency by the angle of the blade relative to the hub.

Mr. BAUCUS. But, let us say the wind is 20 miles an hour, and then it goes to 15.

Dr. Low. You keep changing the blades to take care of the gusts, if you will. The design condition for this windmill is an 18-mile-an-hour wind. At much lower wind speed, it generates less power, but you can maintain efficiency at high winds by maintaining the angle of the blades.

Mr. Baucus. Thank you.

ENERGY CONSERVATION HOUSE

Dr. Low. At Langley Field, we are building what I call here an energy conservation house, but it really is a technology house.

ENERGY CONSERVATION HOUSE



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FIGURE 23

We are applying many of the space technologies in the design of this home.

It has solar panels for heating. It has very good insulation. It recycles water. It uses fireproof paints and many other technologies.

This house is now being built. The estimates are that it will run on about 30 percent of the electric energy of a normal house this size and use only about 30 percent of the water that is normally used in the home. So it is an actual demonstration of the application of space technologies to homebuilding.

Mr. TALCOTT. Just for heating and water? Heating of the air and heating of the water; not cooling?

Dr. LOW. In this application, initially, we will not do the air-conditioning with the solar panels. We have other demonstrations, one at the Marshall Space Flight Center, where we are using solar heat also for air-conditioning.

OTHER APPLICATIONS OF NASA TECHNOLOGIES

Here are still other applications. In the Apollo program, we needed some lightweight tanks for the life-saving devices, both for rescue applications on the launching pad and in the spacecraft itself. That lightweight tank is now being built commercially by a company as a fireman's breathing apparatus.



FIGURE 24

It is lighter; it carries more air. It costs very little more, and it is being marketed now, after being demonstrated in three cities: Los Angeles, New York, and Houston.

This shows an example of medical applications—this is the so-called helicare system, coming out of our Skylab program.

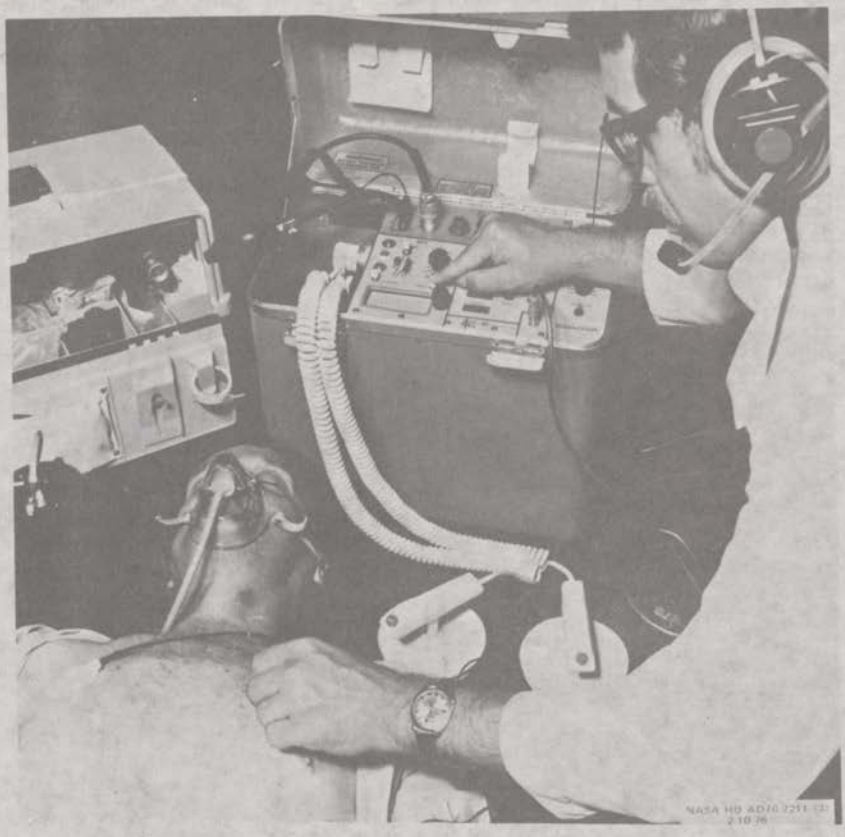


FIGURE 25

We see a red box here that has in it all that modern technology can provide for a heart attack victim. It has the defibrillators to restart the heart, and other resuscitation equipment.

The patient is hooked up with an electrocardiogram. All of this is being sent back by radio signal to a hospital where a doctor can instruct the paramedic in what to do.

The same system is a very small part of the total medical health care system that we are demonstrating in conjunction with the Department of Health, Education, and Welfare at the Papago Indian Reservation, which some of you may have seen on television the other night.

U.S. AND U.S.S.R. SPACE ACTIVITIES

Now, I would like to change subjects and talk very briefly about what the other spacefaring nation is doing, a comparison of our space program with that of the Soviet Union.

U.S. AND USSR SPACE ACTIVITIES

● US ▲ USSR X FAILURE

	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	TOTAL
BIOSATELLITES	▲			▲						X	●	▲	X	●			▲	▲	▲	6 4
EARTH ORBITAL MANNED FLIGHTS					▲▲	▲▲ ●●●	▲▲ ●	▲	▲ ●●● ●●	●●● ●●	X	▲ ●	▲▲ ▲▲▲ ●	▲	X▲		▲▲ ●●●	▲▲▲	X ▲▲▲ ●	27 20
SPACE STATIONS															▬		▬ ▬	▬	▬	4 1
UNMANNED LUNAR MISSIONS		X ▲▲▲ ●●●	X▲▲ ●●●	X X		●●●	X X	●●	XXX XX▲ ●●	X▲▲ ▲▲▲ ●●● ●	●●● ●●●●	▲▲▲ ●	XXX ▲	▲▲▲	X▲	▲	▲	▲▲		33 28
MANNED LUNAR MISSIONS												●	●●●	X	●●	●●				0 9
UNMANNED PLANETARY MISSIONS				XX	XX	XXX XXX ●●	X	XXX ●●	XXX		X▲ ●		X ▲▲▲ ●●		X▲▲ ●●	X▲ ●	X X▲▲ ●●		▲▲ ●●	34 14
OTHER SUCCESSFUL LAUNCHES	1 0	1 1	0 7	0 14	2 29	12 44	12 37	26 53	38 56	38 63	63 48	69 42	57 33	77 27	75 27	71 28	77 17	73 22	83 25	775 573
TOTAL	2 0	1 5	3 10	3 16	6 29	20 52	17 38	30 57	48 63	44 73	66 57	74 45	70 40	81 29	83 31	74 31	86 23	81 22	90 28	879 649

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(REV. 1 1-9-76)

FIGURE 26

First of all, in terms of total flights through the end of 1975, the Soviet Union has had 879 space flights to our 648. If you look, however, at how we started out, in early years, we had larger numbers each year than they had. It was not until the late 1960's that they started catching up over the past several years the U.S.S.R. has flown as we have.

If you look not only at the numbers but at what they are doing, they are covering just about every element of space flight. Although both of us were not always successful in the early years, as indicated by these X's, in later years, both programs have been reasonably successful.

Mr. ROUSH. Are those numbers on the bottom only NASA launched flights?

Dr. LOW. No; they also include military flights.

In manned flights they have an active program. Our only manned flight this last year was in conjunction with the Apollo-Soyuz test project.

In the area of space station efforts, they have a very active program. Their last space station has been up for more than a year. I believe yesterday or the day before yesterday, they returned an unmanned spacecraft that had been attached to that space station for 90 days. So I would expect that we see a major effort continuing in their space station program.

Mr. BAUCUS. Excuse me, Mr. Chairman.

There was an article recently in the paper about the quality of the Soviet military hardware. The estimate seemed to be higher than we originally thought.

Can you tell anything about the quality of the Soviet satellites?

Dr. LOW. I could speak at firsthand about the manned program, because we saw their hardware in the joint Apollo-Soyuz project. In terms of mechanical hardware, it was essentially equal to ours. In terms of electronics, particularly in terms of their computer hardware, it was a number of years behind. They had in the Souyuz spacecraft essentially what we had in Gemini, which flew in the middle 1960's. So they are behind, clearly, in computer technology and high-level electronics.

They are probably as good as we are, or perhaps even better, in some of the mechanical gadgetry. They have some catching up to do in other areas.

I think this brings me back to what Dr. Fletcher talked about in the beginning. The Soviets have a huge effort in their space program and their total technology program. Whether or not they are ahead of us or behind us on any given day in space is less important than where they stand in overall technology.

As we are coming down in our NASA spending, we are coming down in technology, and, therefore, down in the overall productivity and efficiency of our entire economy. I become very much concerned when I see another nation that keeps on building in its high technology efforts because research and technology are forcing functions in a nation's economic growth and strength.

Mr. BAUCUS. There is some speculation about the use of laser beams to knock out satellites. What is going on there?

Dr. FLETCHER. Of course, that is a military program, and we do not have any first hand knowledge of military programs. But it is quite possible that if you have a satellite that uses photographic techniques or infrared, like some of our weather satellites, I think a laser beam would do serious damage to it.

Mr. BAUCUS. Do you not have some knowledge of how well your satellites are operating?

Dr. FLETCHER. Yes. They have not damaged any of our satellites that we know of.

Mr. ROUSH. Thank you.

Dr. FLETCHER, could we come back at 1:30? Is that too soon?

Dr. FLETCHER. No; we will be glad to be here at 1:30.

Mr. ROUSH. The committee will stand adjourned until 1:30.

AFTERNOON SESSION

Mr. ROUSH. The committee will come to order.

ECONOMIC IMPACT OF NASA PROGRAMS

Dr. Fletcher, this morning you made comments to the effect that NASA-type expenditures in high technology projects have the advantages of being less inflationary in the short run, and more beneficial to the economy in the long run. Closely tied to that statement is the point that you make that:

> There is no way in the long run that our economy can grow with unemployment reduced and inflation held in check except by increasing productivity; and increases in productivity depend on developing advanced technology.

I take it you feel that the investment of Government dollars in NASA is the right way, or at least one way, of getting that productivity moving.

Dr. FLETCHER. I certainly do, Mr. Chairman. I do not mean to say that we should not encourage private investment in high technology. But I think as far as Government spending is concerned, we should be very careful about cutting back on Federal expenditures for high technology, because a large fraction of what this country spends is spent by the Government at the present time.

Mr. ROUSH. Have you been able to make that point to OMB? I should not say, have you been able to make it; I am sure you have pressed the point. But has your argument had any appeal to OMB?

Dr. FLETCHER. Mr. Chairman, as you know, the personnel in OMB keep changing, and we make the point with each new group as it comes along. I think, generally speaking, that they are sympathetic with the point that investment in high technology is beneficial in the long run for the country. Some would rather have it spent by private industry than by the Government.

Mr. ROUSH. But you point out in your testimony—and it was pointed out rather forcefully here this morning—that your budget has been consistently declining in constant dollars. This would seem to indicate that you have not sold your message to OMB or to the President.

Dr. FLETCHER. Mr. Chairman, I think that the President is well aware of this facet. But I think that in the case of this particular budget, it would have been difficult to add money for technology in NASA's budget, considering the President's efforts to restrain Federal spending. I think this is a short-run situation, and I hope that the outlook is promising.

PUBLIC SUPPORT OF SPACE PROGRAMS

Mr. ROUSH. Could part of the problem be that you have lost the support of the American people; that you no longer appeal to their imaginations and to their desire to have dramatic things happen? Could that be one reason that you are having difficulty here, and that your budget has, in constant dollars, been declining?

Dr. FLETCHER. I certainly think that is one factor, Mr. Chairman. The public's imagination is not as excited as it was during the Apollo landings. I think that partly as a result of the spectacular successes that we had on Apollo, people tend to have a completely wrong idea of how much is being spent on the space program. Actually, it is a

very small percentage of the total Federal budget, as Dr. Low pointed out. NASA spending is less than 1 percent of the total Federal budget; and in that sense, I think some education of the public is necessary. People may not realize how little is being spent on NASA compared with other programs.

PUBLIC INTEREST IN NASA

Mr. ROUSH. In recapturing the imagination of the American public, is there any other way you can do it? Do you see anything happening in your program right now, or in the immediate future which would cause the American people to get excited about your program, and lend itself to an education program that will fall on receptive ears?

Dr. FLETCHER. I think there are several things happening, Mr. Chairman, all of which will make the public more excited. First, the public is becoming more and more aware, daily, of the benefits today of the investment in space yesterday. There are a number of programs on television, for example, which point out the benefits of space, the spinoffs.

There was one on NBC, for example; and last week during the Olympic Games there was a series of highlights. That is one way that the public will become more interested. There are a number of events that are happening in NASA which I think will be very exciting. This summer will be one of them, when we land two very sophisticated automated spacecraft on the planet Mars, a long-time dream of people. We will land on two different places on Mars, and look for signs of life. But I think the thing that will be interesting to the public is that we will send back photographs of the landscape. And if the landscape changes, we will photograph changes in that landscape—color photographs of what that planet is like. It is going to be quite different from the Moon, for example. It is a different kind of a planet. But it is also different from Earth.

The Viking landings on Mars will, I think, excite the public. And I think the public will begin to be quite interested in the unique capabilities of the Nation's reusable Space Shuttle and what that can do. They will be able to not only watch this vehicle take off routinely, but for the first time they will actually be able to see it land and be ready for other flights. The Space Shuttle will land on an airstrip instead of out in the Pacific Ocean, as we did in our Apollo flights.

SPACE SHUTTLE BUDGET AND SCHEDULE

Mr. ROUSH. You have led us into a series of questions here on the Space Shuttle. For the last 3 years you have been telling us that the Shuttle program could not afford any more cuts. And yet each year, OMB seems inclined to cut the program. How can you reconcile these statements of yours that you cannot afford the cuts with the action of OMB?

Dr. FLETCHER. Mr. Chairman, that is a very good question, and we had to do this very carefully this year. Last year, if we had been forced to cut the Shuttle $100 million, it would have had a far more serious impact on the Space Shuttle development. However, the bulk of the fiscal year 1977 reduction was in deferring the start of the production of the third orbiter, not in the development portion of

the program. The development, the D.D.T. & E. as we call it, includes the first two orbiters. The third orbiter was supposed to have started production in fiscal 1977, but we have had to delay the start of production of the third orbiter—the first production vehicle—until fiscal year 1978. We also had to defer selected activities in the development effort that were not absolutely critical for the first manned orbital flight (FMOF).

So, the first two orbiters will be on schedule. The first orbiter will be used for approach and landing tests beginning at the end of calendar year 1977. The second orbiter will be used for the first manned orbital flight in 1979, as planned.

Rollout of the first orbiter is planned for September of 1976. Work on the second orbiter is progressing on plan, leading to the first manned orbital flight planned for 1979. The major milestones are on plan.

Mr. ROUSH. The Shuttle, on that landing test, will not be a complete Shuttle, will it?

Dr. FLETCHER. It will only be the orbiter, Mr. Chairman.

Mr. ROUSH. Even that will not be complete, will it? Do I understand that the protective coating, the tile-like material that will be on the Shuttle when it does make its first space flight, will not be on that particular first flight?

Dr. FLETCHER. There will be some differences. Would you like to point them out, Mr. Yardley?

Mr. YARDLEY. Basically, it will be a complete orbiter, to the extent that it is necessary to do those approach and landing tests. Now, it will not have all orbital systems in it. We will simulate the TPS so that we will have the same aerodynamics.

Dr. FLETCHER. That is the thermal protection system, the TPS.

SPACE TRANSPORTATION SYSTEM COSTS

Mr. ROUSH. The subcommittee, of course, will have many questions concerning this program and other programs. We are trying to anticipate trouble spots, not only with the Shuttle, but other NASA programs. For example, we are concerned about user costs. Questions have been propounded for the last 2 or 3 years concerning user charges; questions concerning the commercial customers for the Shuttle, and some of the comments that have been expressed to us concerning Shuttle costs.

We are also concerned about informal comments from the Defense Subcommittee, which has raised important questions about DOD's use of the Shuttles and related costs. In the same area, we are concerned about interim upper-stage costs, and just how effective a Shuttletug mission might be. We are going to be exploring all of these areas in the next couple of days, and I know you will be forthright in your answers. What I am trying to emphasize is that there is deep concern on the part of the subcommittee about these various questions. Therefore, there will be some probing, not only during the hearings, but these might be followed up with other questions which would be in a written form.

Let us start by reviewing the Shuttle and other costs. I am going to go through a review of the space transportation system costs, and you might tell me if it is correct. In constant 1971 dollars, the various elements break down as follows.

The Shuttle design development, test and evaluation—$5,220 million. That is an increase of $20 million above last year's estimate in constant 1971 dollars and reflects the reduction built into this year's fiscal year 1977 Shuttle request. Is that correct?

Dr. FLETCHER. Yes, those are in 1971 dollars, Mr. Chairman, and it is correct; the estimate does include the extra cost, due to the fiscal year 1977 budget reductions.

Mr. ROUSH. Next, we add to the $5,220 million an estimated $300 million for NASA facilities. Now, that number has not changed. Is that correct?

Dr. FLETCHER. That is correct, Mr. Chairman.

Mr. ROUSH. Next, we add $1,060 million to cover the cost of refurbishing two development orbiters, and procuring three production orbiters. That estimate is up in constant 1971 dollars by $60 million above last year. That increase reflects the effect of deferring the start of production of the third orbiter until fiscal year 1978. Is that correct?

Dr. FLETCHER. That is correct, Mr. Chairman.

Mr. LILLY. May I just clarify one point, Mr. Chairman? That is correct as far as decisions have been made now. As you know, the decision was made to defer the initiation of production of Orbiter 103—the third orbiter, which is the first production vehicle. No discrete decision was made on the follow-on two orbiters—that is Orbiters 104 and 105. If I assume they are going to be delayed in the same way and stay in the same line, that could well have the same effect on those two other orbiters downstream. If that were to be the case, then your number would be about $1.2 billion in 1971 dollars.

But, as I said, the number you have given now is correct, as far as a decision has been made at this point.

Mr. ROUSH. Thank you.

Next, we have to add the cost of the research, development, and testing of an interim upper stage. In constant 1971 dollars, that should be between $135 million and $150 million. Is that correct?

Mr. LILLY. That is our understanding of the estimate that the Air Force is now using, and has most recently been reported by the GAO.

Mr. ROUSH. Next, the cost of facilities for the western test range under the DOD budget in constant 1971 dollars is estimated at $500 million. Is that correct?

Mr. LILLY. That is correct, Mr. Chairman. There are a number of studies going on. In the latest study I have seen, they have not made a final decision. The latest estimate that I have seen, in the dollars of the fiscal year 1977 budget, is about $710 million. If that is the case, if they finalize on that number, it will come in a little less than the $500 million in 1971 dollars. But we have no basis on which to change it at this point.

Mr. ROUSH. Now, when all those elements are added up in constant 1971 dollars, the total comes to about $7.2 billion. Is that correct?

Mr. LILLY. That is correct, sir. Those are included in the STS nonrecurring cost estimates.

Mr. ROUSH. Now, let us see what we have left that must be added to make the space transportation system complete. Now, I will go down the list, and you fill in the blanks.

The Europeans will furnish NASA with one Spacelab free, and we will buy at least one additional lab. What will that cost in constant 1971 dollars?

Mr. LILLY. The amount that we estimate for the one we would buy, in 1971 dollars, will be about $30 million.

Mr. ROUSH. Now, $30 million, you say?

Dr. FLETCHER. That is very approximate, Mr. Chairman, because Spacelabs do not come as a standard unit. A Spacelab is a combination of hardware components, such as a core segment, pallet segments, experiment racks, and other elements. That is an estimate of the series of components that we would buy.

Mr. ROUSH. Now, what other costs must be added to complete the space transportation system?

Mr. LILLY. Mr. Chairman, if one refers back to the earlier mission models, and assumes the development of a follow-on, fully reusable tug, then that amount would also have to be invested. That amount for space tug development, in 1971 dollars, was about $638 million. The probability is that with the development of the IUS, we will delay the tug somewhat. Dr. Low referred to that possibility this morning.

In addition, if you follow on from that, and buy an initial increment of reusable tugs, our initial estimates, in 1971 dollars, would be about $171 million; and there is no reason to change that estimate at this point. And I believe those are the total numbers, the balance required to fly the 581 mission model that we have referred to.

I would like to note, Mr. Chairman, that our whole estimate assumes the availability of our civil service people. If one were to prorate the R&PM costs or the personnel costs of the NASA civil service personnel or the DTMO services at our Centers, that would add some more money. We have never included those in the cost, since these functions and services are required to carry out NASA's operations, with or without the Shuttle.

The other kinds of thing such as certain training costs involved, operation of the simulators, the training aircraft and things of this nature, are all priced out in the cost per flight and are contained therein.

Mr. ROUSH. Now, have you left anything out?

Mr. LILLY. I do not think so, Mr. Chairman.

Mr. SHIPLEY. Will the chairman yield?

SHUTTLE PAYLOAD COSTS

Mr. SHIPLEY. What about the cost of the space telescope?

Dr. FLETCHER. I think we always have to differentiate between the Shuttle, which is a transportation system, and the payloads.

Mr. SHIPLEY. I understand that. But there has to be some cost-related factor if you are going to carry the LST on the Shuttle.

Mr. LILLY. The Space Telescope would be one of the payload costs.

Dr. FLETCHER. Yes; and there will be other payloads; some paid for by NASA, and some paid for by other agencies, some paid for by international groups. But that is all under payloads, just as we charge payloads now that are transported on expandable launch vehicles.

TOTAL ESTIMATED COST OF THE SPACE TRANSPORTATION SYSTEM

Mr. ROUSH. Now, if your list is complete, and you have not left anything out, what would the total cost of the space transportation system be in constant 1971 dollars?

Mr. LILLY. Using the STS nonrecurring costs that we went through, in 1971 dollars, the original cost estimate that we had when the Shuttle was first started, before any deferrals or increases in the Shuttle DDT & E, was, I believe, $8,050,000,000. It would now be about $8,052,000,000 in 1971 dollars. That takes into account the difference between the $5.15 billion original estimate (1971 dollars) for the Shuttle development which is now $5.22 billion, also in 1971 dollars, as a result of the budget reductions.

Then there is a slight reduction in the IUS, which is less than what would have been used in flying the mission model using expendable upper stages. If I assume that Orbiters 104 and 105 will also be delayed, the current estimate for all those items of nonrecurring cost would be about $8,192,000,000.

Mr. ROUSH. If the total cost in 1971 dollars were expressed in real year dollars, what would that figure be? I am asking for the real year dollars, to include anticipated inflation through completion. If you do not have that now, would you supply it for the record?

Mr. LILLY. I can give you that now, Mr. Chairman. Let me do it in two parts.

In the dollars of the fiscal year 1977 budget, that equates to about $10,800,000,000. If I assume that the inflation rate will continue in our R & D work at about 7 percent and that our construction work will experience an average inflation rate for the balance of the time of about 10 percent, then the total Space Transportation System nonrecurring cost in real year dollars would be about $12 billion— $12.384 billion.

GAO STAFF STUDY ON THE SPACE SHUTTLE

Mr. ROUSH. Now, continuing this discussion on cost, let us return to the GAO's new report on the Shuttle. Understandably, we expect you will have problems with the report, and we are just going to lay it out here and see what happens. To begin with, the GAO indicates that Shuttle costs can be expected to exceed, by more than $1 billion, NASA's original development cost estimate. They point out that this is because of increases in inflation in excess of that originally projected, and delays in the timing of expenditures and transfers of Shuttle work to other program elements in the NASA budget.

GAO contends that a cost growth of approximately $524 million is directly attributable to an increase in the rate of inflation from 5 to 7 percent. I believe NASA does not agree with this analysis. It may be somewhat unfair to count inflation as a cost growth factor in any program. However, the GAO also concludes that NASA's decision to defer work, including testing scheduled for the development phase to a later time period, has increased costs by $426 million.

What is your response to that charge?

Dr. FLETCHER. We will answer that in two parts, Mr. Chairman. As far as the escalation part is concerned, I think Mr. Lilly is best prepared to answer that. I would ask Mr. Yardley to address the technical part.

Bill, do you want to answer the escalation part?

Mr. LILLY. I think the GAO allegation is completely wrong. I think it is a matter of record that the Shuttle commitment was made in 1971 dollars. The original Shuttle development cost estimate of $5.15 bil-

lion was made on that basis, to be updated annually to include the impact of inflation.

Therefore, I do not believe, as you indicated, that it is fair to call that a cost growth. It certainly is escalation, and we anticipated that there would be inflation. But we did not try to forecast it out into that time period.

Now, GAO refers to a change between 5 and 7 percent. In last year's report, and I believe this year GAO says that NASA people were estimating inflation rates on other projects at approximately 5 percent. GAO then states that if NASA had estimated inflation on the Shuttle, it would have been at 5 percent. Using their assumption, I think they gave a number of $5.9 billion or something like that. However, NASA management never gave or estimated it at 5 percent. So that is incorrect.

GAO also alleged that NASA would incur a cost growth of $426 million because of decisions that NASA made in deferring tests. Those tests or items were deferred when our fiscal year 1975 and 1976 budgets were reduced, and those items were pushed further out in time. We did indicate the increase to our D.D.T. & E. estimate in 1971 dollars; and if inflation continues, more inflationary costs will occur than would have occurred on the original schedule.

Now, as far as reconciling their other items is concerned, I have just recently seen their draft report, and I cannot reconcile it to what actually occurred.

Mr. ROUSH. Are you saying here that those delays were principally related to OMB funding constraints?

Mr. LILLY. That is correct, sir.

Dr. FLETCHER. I think what we are also saying is that the increased costs—and I think you added them up correctly just now—are the result of escalation. We calculated all of our estimates in terms of 1971 dollars. The only exceptions are the amounts that we indicated; namely, there was a $50 million increase resulting from the stretchout caused by the OMB reduction in fiscal year 1975 and another $20 million in the D.D.T. & E. due to the fiscal year 1977 cut. There is also the $60 to $70 million increase, plus inflation, in the production costs due to the deferral of starting production of the third orbiter until fiscal year 1978. What we are also saying is that to the best of our knowledge, there is no increase due to technical difficulties in the program, or places where we have rearranged the testing program, or any of that sort of thing. There is no increase at all in our estimate due to those factors, and that is what I would like to have Mr. Yardley comment on.

Mr. YARDLEY. That is correct. I do not think we quite made it clear that that $426 million is also escalation. When we have to take something out of 1 year and put it 2 years downstream, it costs the same in 1971 dollars, but it costs more in inflated dollars. That is what that $426 million is made up of. Therefore, the $1 billion cost growth cited by GAO escalation, except for the $70 million increase to our original $5.15 billion D.D.T. & E. in 1971 dollars, resulted from OMB funding reductions in fiscal year 1975 and fiscal year 1977.

Mr. ROUSH. Can you break that down as to the amount you feel is attributable to delay, and that which is attributable to increased costs by reasonable inflation?

Mr. YARDLEY. Yes, sir; $50 million attributable to the fiscal year 1975 stretchout and $20 million resulting from the fiscal year 1977 reduction. These increased our $5.15 billion original D.D.T. & E. estimate to $5.22 billion, 1971 dollars. That $70 million is the cost growth, and it is all attributable to the impact of funding cuts. The rest of that is having to put things downstream, which costs more in real year inflated dollars.

Dr. FLETCHER. We may not get exactly the same number, because that is the one that Mr. Lilly had a hard time reconciling. But we will get a number that is right, and it might be approximately what you indicated.

Mr. ROUSH. Now, finally, the GAO has identified $195.5 million of cost growth in the Shuttle program and it contends that NASA has transferred that amount from the Shuttle budget to other NASA budgets, or to the operational phases of the Shuttle program. Would you answer to that, please?

Mr. YARDLEY. Yes, as the program matures, and other events occur, there are continuing support functions that are traditionally provided in other budget categories. For instance, we have a development, test, and mission operations budget item under space flight operations that runs about $170 million a year. That category includes items such as mission simulators and other support functions. We have tried to be consistent in our bookkeeping in terms of what is a Shuttle cost, and what is a continuing support cost. There have been minor changes, and our reconciliation shows that there have been $111.7 million, not $195 million. That reconciliation is shown in the appendix to the GAO report.

We decided to do the integration of the solid rocket booster in-house at the Marshall Space Flight Center. That saved us an estimated $58 million.

Another item that GAO refers to is the remote manipulator arm, a $23 million item. The Canadians agreed to develop it. The GAO has said that would have been overrun if we had done it. Those are the kinds of things that they are referring to.

Mr. ROUSH. If these costs are being absorbed by other budgets, does it not make it next to impossible to evaluate the program's cost status in order to determine precisely where you stand in relation to meeting your original cost goals?

Dr. FLETCHER. Mr. Chairman, I think we can state exactly where we stand, in each case, in comparison with the original cost goals. There are some small items which, to be sure, add up to approximately $100 million. But we can account for every dollar of those, and we can give you the correct tabulation of them, and where they all went, if you are so inclined.

Mr. YARDLEY. The other thing I would like to point out, and maybe Dr. Low would want to amplify on this, is that the $5.15 billion commitment in 1971 dollars on the Shuttle development assumed that we would have these other functions and funds, like the R. & P.M. and the development, test, and mission operations, available.

Those funding lines have gone down rather than up, so anything we can absorb in those is actually over and above what we had committed to.

Mr. ROUSH. Dr. Fletcher, if you can supply this for the record, in view of the General Accounting Office's charge, I think it might be helpful.

Dr. FLETCHER. We would be happy to. Although it is hard to keep track of these, we have kept track of them because we made this very solid commitment—I don't know of any other program that made it—but we made a commitment that we would accomplish this development program for $5.15 billion within an overall NASA annual budget of $3.4 billion in constant 1971 dollars. And we are holding to that Shuttle D.D.T. & E. commitment.

We have kept track of every penny that goes in and out of Mr. Yardley's budget, so we would be happy to supply that for the record.

[The information follows:]

It is our position that there have been no "budget transfers." As the Shuttle program has proceeded and definition activity on the program elements become more firm, decisions have been made as to the proper funding sources for budgeting purposes. These decisions have been consistent with the Agency's budget structure and procedures. There certainly has been no decision made for the purpose of avoiding a commitment limitation. The original commitment on Shuttle development was that we would develop the Shuttle at a cost of $5.150 (now revised to $5.220) billion in 1971 dollars within a total annual level agency budget of $3.4 billion in constant 1971 dollars. Even though the total agency budget level has continued to fall below the committed level, we will complete the Shuttle D.D.T. & E. within the commitment made. Individual decisions will continue to be made, as items and contracts are firmed up, to proceed in the most cost effective manner consistent with NASA's approved budget and accounting structures.

Although we do not accept the GAO's assumption of "transfers," we have taken actions to establish proper funding sources which have impacted the D.D.T. & E. budgeting as summarized below.

The following activities were initially conceived as Shuttle D.D.T. & E. requirements:

Solid rocket booster preliminary design efforts are being performed in-house at MSFC rather than by a separate R. & D. contract.

A forward fuselage section originally planned for use as a test article (test now deleted) and then on a production vehicle is now to be funded in Shuttle production since the D.D.T. & E. requirement for the test was deleted.

Facility ground support equipment (GSE) required at KSC for operational shuttle flight rates has been separated from that GSE needed to establish the launch processing capability required for the D.D.T. & E. flight activity. The GSE for D.D.T. & E. requirements is budgeted under D.D.T. & E. and that required for the operational flight rates is to be funded under production.

Government furnished equipment required for the first production orbiter vehicle and for the Orbiter 101 modification during the production phase is now to be funded in production.

The remote manipulator system development to be undertaken by Canada rather than NASA.

The program requirements now included in D.D.T. & E. which were previously assumed to be in other budget activities include:

Reconfiguration of the mission control center at the Johnson Space Center to provide the capability to support the Shuttle development flights.

Design and development of a class of equipment for the orbiter to provide a general use vehicle operational support capability.

Continuation of main engine testing beyond the development flight period to demonstrate engine life expectancy.

Using the GAO assumptions, the so called transfers would be as follows:

	Approximate amounts in millions
"Transfers" from D.D.T. & E. to other budgets: Booster development activities	$58.0
"Transfers" from D.D.T. & E. to production orbiter development	118.0
Launch and landing development	70.0
Other "transfers" from D.D.T. & E.: Remote manipulator arm development	22.7
Subtotal	268.7
Less "transfers" from other budget activities to D.D.T. & E	157.0
Net "transfers" from D.D.T. & E	111.7

SPACE SHUTTLE USER CHARGES

Mr. ROUSH. Now, I imagine that the ultimate test as to the value of the Shuttle depends on its use.

Let's talk about user charges.

What is NASA going to charge COMSAT, RCA, NOAA, NATO, and others who may use the Shuttle system?

Dr. FLETCHER. We have not fully decided what the charges will be. We are studying the pricing alternatives. We have a pretty good idea of what the costs are going to be. As you know, Mr. Chairman, the first article always costs a little more and the second article a little less, and by the time you are up to 20 or 30, then the cost begins to come down to a more level price.

On the other hand, we think we have to decide this year what we are going to charge users, because they are trying to decide whether to use expendables or the STS Shuttle. We hope to have that pretty well firmed up by the end of this year. At that time, we hope to come up with an estimate of what we are going to charge the users for Shuttle flights.

SHUTTLE COST PER FLIGHT

This is a complex subject because there are many different shapes, sizes, and estimations of payloads.

Mr. ROUSH. The one cost we did not discuss is the cost of the initial Shuttle operations. For the past 3 years you've testified that the cost per flight in constant 1971 dollars would be about $10.5 million. But that figure represents the average cost for, as I understand it, the entire 11-year, 572-mission model. The initial cost to operate the Shuttle will be a great deal higher.

Now, perhaps you could tell us why a substantial operations fund will be necessary if the Shuttle is going to have a chance to compete with the conventional boosters?

Dr. FLETCHER. Yes; I want to be sure to clarify the difference between costs and charges. The average cost is still $10.5 million per flight, in 1971 dollars, but we don't want to get costs confused with charges. Charges depend on how many different payloads we put on each flight and other factors. The charges will have to be made on a per-pound or per-volume basis. So charges and costs are different things.

Now, with respect to the operational fund, as you suggest, I am not sure there will be an operational fund. This was one concept that

we looked at last year, to take account of the early-year funding, but most of that requirement occurs in the first 2 or maybe 3 years. The first years could be considered to be research and development flights, and as a result there may not be too many customers during that period. I think that a portion of that early funding could very well be considered as research and development activity, much the same as you charge research and development off in the first new automobiles. You don't try to recover the full cost all at once.

We have not made up our minds on how to deal with that. We hope to have it squared away by the end of this year.

Mr. ROUSH. That is still going to take a great deal of money.

Dr. FLETCHER. The number of flights in the first 2 years is not large. I think during the first year there are only three Shuttle development flights. The second year there are three development flights, and maybe another three or four or five customer flights.

DIFFERENCE BETWEEN SHUTTLE COST PER FLIGHT AND COST TO OPERATE

Mr. ROUSH. Now, you say only three to five flights. I notice the average is $10.45 million cost per flight averaged over a period of time.

What would the cost for those first three or four or five flights be? It would be considerably more than the $31 million represented by an average of $10.45 million, would it not?

Dr. FLETCHER. It depends on how you count research and development. If you count that as part of research and development cost, you may come out with a number closer to the $10.45 million.

Mr. LILLY. Mr. Chairman, if I could elaborate just a moment, the $10.45 million that we set as our goal, in terms of the cost per flight, was, as you correctly state, an average cost, calculated on a breakeven position over 11 years.

In other words, as you say, the average cost per flight will start off higher. When you come down the learning curve, the breakeven point on this curve will occur at about 115 flights. Then you will go slightly below that, and over that entire time period the average cost per flight, in 1971 dollars, will be approximately $10.5 million.

Now, what is the first unit cost per flight and how does it come down over time?

At the flight rate we are projecting right now, I believe the average for the first year is around $35 million in current budget dollars. It comes down quite rapidly on a fairly steep curve to about $21 million; and then on down more gradually from there.

The target cost per flight estimate of $10.5 million in 1971 dollars was established to assure that the Shuttle efforts fully considered the impact on the cost per flight.

Included in the cost per flight are all of the direct operating costs that are required in order to fly the Shuttle itself. That includes our in-house civil service costs and efforts of this nature, as well as the expendable external tanks that we would have to replace on each flight, launch, flight control and recovery, and refurbishment.

The "cost to operate" is associated with the whole space transportation system and includes the costs to support the Shuttle, IUS, Spacelab, integration and general mission, and payload support, as well as an allocated share of indirect support costs—NASA and WTR.

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We have been conducting studies and discussions with OMB, and a number of people are looking at the problem of establishing a valid charge estimate early enough to provide the customers a price 3 years before flight. If we do that, and run it on a working fund basis, then we would have to have an operating fund to buy inventory, and things of this nature, to start with. It's like any other new service; you would be operating initially at a loss for the early period. You would have your over and under accounts; and then you would break even as you move on down the learning curve.

Now, what Dr. Fletcher referred to is that there are other ways of doing it. One approach is the direct appropriations method during this first 2 or 3 years of initial operations. Then the Government would recover those costs later on downstream.

Mr. ROUSH. Dollars are still there, aren't they?

Dr. FLETCHER. Dollars are still there, but it is still in the experimental transition period.

Mr. LILLY. You have probably seen that the President's fiscal year 1977 budget includes a budget projection for NASA. There is a table on page 36 of the President's budget where they project budged authority of $3.7 billon in fiscal year 1978. Then it drops down to $3.5 in fiscal year 1979, $3.4 billion in fiscal year 1980, and $3.1 billion in fiscal year 1981. Their projections exclude provisions for inflation beyond fiscal year 1977 and for next step NASA activity after fiscal 1978.

But these projections in the President's budget do include funding estimates for these initial operational costs and for the inventories. So these funds have been included within budget projections.

Now, the problem is to determine a funding mechanism over the period of time one takes in recovering costs. Do you make the first one pay for the full incurred amount, or on an average? Our basic belief is that it should be done on an average basis.

COST FOR TITAN EQUIVALENT LOAD

Mr. ROUSH. Let's take an example here—the bread-and-butter booster used by the Air Force, the Titan III–C.

The Titan cost is in the range of $40 million to $45 million per shot.

Is that correct?

Mr. LILLY. Yes, Mr. Chairman, it's about $47.1 million, I believe, for non-Government users.

Mr. ROUSH. Now, for planning purposes, NASA has advised the Air Force that it will charge DOD approximately $19.4 million for a Titan equivalent load on the initial Shuttle flights; is that correct?

Mr. LILLY. I believe that is a preliminary planning estimate in 1975 dollars, including the estimated indirect costs.

Dr. FLETCHER. That's a talking number.

Mr. YARDLEY. It is a rough number that we gave them for planning purposes.

Mr. LILLY. There is an STS—Space Transportation System Committee, of which Mr. Yardley is the cochairman—in which they are continually reviewing these considerations, such as what our costs will be at some point in the future. I think that was the number provided to DoD last fall.

Mr. ROUSH. So the answer is "yes." The actual cost of those Shuttle flights, as I understand you, however, will be in excess of $40 million.

Mr. LILLY. The average for that first year would be about $35 million.

Dr. FLETCHER. I think the Air Force would get a bargain on that one, but I think it is not accurate to assume that the $19 million is what we will actually charge.

Mr. YARDLEY. I think there is a problem here of a distorted view of how much we are talking about over the first flights which it takes to reach a break-even average cost. We are talking about something like an average loss of $4 million a flight before we start recovering funds over actual costs.

Mr. ROUSH. Now, let's get back to Dr. Fletcher's comments.

He said that the $19.4 million is a distorted figure; but a moment ago I thought you said that was the figure.

Dr. FLETCHER. That is a talking figure. But at $19 million, they would get a pretty good bargain.

Mr. ROUSH. That is what I was going to point out. They get a mighty good bargain, it seems to me, so you have a loss incurred here.

Dr. FLETCHER. Actually they have a gain; we don't have a loss. The Shuttle is less expensive and more versatile than the Titan.

SHUTTLE USER CHARGES

Mr. ROUSH. So DoD is transfering to NASA the cost of an operation which rightly belongs to DoD?

Dr. LOW. I think we have to come back to your opening remarks, Mr. Chairman, that we have not yet decided in detail what our charging policy will be. That is what we will study during the remainder of this year, so any estimates that we are talking about now are only very preliminary planning numbers.

The facts are that we are going to come up with—in a business-like manner—a charging policy that will let the costs and charges fall where they should fall, where everybody will get the advantage, ultimately, of this new, flexible tool called the Space Shuttle. It is bound to be a better buy for everybody than a 1960 booster called the Titan.

Mr. ROUSH. Is there a need—and perhaps we should term it, "a critical need"—to establish a pricing structure which is low enough to drive out the competition if we are going to sustain our advocacy of the Shuttle program?

Dr. FLETCHER. Mr. Chairman, I don't believe there is a need to do that. I think it will happen naturally, because of the Shuttle system's unique capabilities. This will be a much cheaper vehicle, especially in comparison with Titans, but probably also Atlases and very likely Thor Deltas.

There is another point that I should mention, because I don't want to mislead anybody. Before we establish a pricing policy, we are going to discuss it with the committee and many other people. Since the policy is going to hold for a long period of time, we are not going to develop it without a thoroughly coordinated effort with you and others who are concerned. This includes many people.

Mr. ROUSH. What if we don't appropriate those funds that relate to this "operating loss"?

Dr. FLETCHER If you don't appropriate the funds, we will not be able to operate the Shuttle.

Mr. ROUSH. I did not intend to say that. You are asking us to appropriate a little extra money here in order to sustain what I would call a loss.

Dr. FLETCHER. At this point, we are not asking the committee for any funds for that period of time. But we do plan to explain to you before the end of this calendar year how we propose to charge customers. Determining this policy is not an easy process; it is a complicated process. We are learning the freight business, shall we say.

Mr. LILLY. If I may, Mr. Chairman, in terms of a number that may be quoted, such as the $19.4 million for the Air Force flights, it represents an estimate, at that point in time. If one establishes that number as a charge for planning purposes, one might also keep it, even when the flights cost less than that. It is more important to make it break even over the total period of time, rather than in that particular period. It is important, particularly in terms of commercial customers and also in terms of DoD. There certainly needs to be some stability in pricing over a period of time; however, as Dr. Fletcher mentioned, we are looking at all aspects of this complex subject—what the inventory requirements are; what is a reasonable flight rate that we need to build for; what funds are necessary in order to carry out those flights, and how the pricing policy would work. Then, of course, we would meet with the committee to discuss the considerations, including the proper mechanisms. For instance, is it better to do it through an operating fund so that you will break even over 3 or 5 years; or is it better to charge each customer what each article costs and let the succeeding customer get the benefits each time?

As Mr. Yardley indicated, we are studying these issues and we will be discussing this with you in much greater detail later this year.

SHUTTLE-COMBINED PAYLOADS

Mr. ROUSH. Let's take another question that will lead us to another question involved here. Let's take the Delta booster. Today's average Delta launch vehicle, with a capacity of about 1,500 to 2,000 pounds, will cost a Government user about $7 million, and a commercial user, such as Comsat, about $13.5 million.

Even after the flight rate builds up, I assume there is no way the Shuttle can be cost effective if you were flying single, Delta-sized payloads.

Now, the point is that for the Delta class payload, the key to the Shuttle's cost effectiveness rests with NASA's ability to combine payloads; is that correct?

Dr. FLETCHER. That is correct, Mr. Chairman.

Mr. ROUSH. Now, would you tell the committee how you plan to do that?

Dr. FLETCHER. Again, this is part of the pricing policy, but I can give you a picture of it. It depends on what kind of upper stages you use. Using the kind of upper stage that Thor Deltas use, a kind of relatively inexpensive, spinning upper stage, you can actually combine four Thor Delta-type payloads into one Shuttle load.

Now, that's tight packing, but you can actually get them in.

We should not figure on four; we should probably figure on something like three; and if you figure three of these Thor Delta payloads

for every Shuttle load, you will find that the costs average out less than the Thor Delta cost.

In other words, the figure would come down at least 20 percent. I don't know the exact figure, and we are not through the calculations yet. But the plan would be to carry three of those typically.

Mr. YARDLEY. I might point out that you don't necessarily have to carry three or four Thor Delta payloads. A Thor Delta payload only uses one-fourth of the Shuttle capacity, so you can take other payloads with it. The Shuttle can be shared.

Mr. ROUSH. From what you said, it is apparent that the entire concept of this combining or bundling payloads is basic to the cost effectiveness of the Shuttle.

Now, let me read from the GAO report again.

> From a practical viewpoint, a number of obstacles in combining payloads exists; for example, payload weights, dimensions, and orbital requirements must be compatible. Several payloads must be developed and available for the same Shuttle flight. A schedule slippage of one payload could increase cost to the others, potentially invalidating the expected savings of the multiple payload flight.

Now, what is your reaction to that?

Dr. FLETCHER. I think we do have to schedule payloads very carefully, and we do that now. When we have to adjust flights around now with Thor Deltas, it costs a little extra money.

In fact, not too long ago we had to reschedule some payloads, and it cost the customers some extra money. We charged the customer for that additional effort.

But what you say is true: We do have to be much more careful about scheduling these combined payloads during the STS/Shuttle era.

Just so that your mind is set at ease, there are many Thor Delta flights, even now. I think Dr. Low indicated it earlier. It is two-thirds, probably, of the total. In the period 1979–80, there will be probably around 15 Thor Delta-type flights. It appears that these can be combined reasonably well so that you could put two or three such payloads on one Shuttle flight.

Dr. LOW. The point, Mr. Chairman, is that GAO analysts can assume these obstacles, but they have no basis in fact. We are in a very precise business; we do know what payloads weigh and what size they will be; we do know when we launch them, and we do expect customers to want our launch services. We see no difficulty in combining two or three or four payloads on a Shuttle flight.

1976 PAYLOADS

Mr. ROUSH. All right, Dr. Low, fine.

Now, just for purposes of illustration, would you provide for the record how you would have combined the payloads for the current year, 1976.

Dr. LOW. I would be glad to do that, Mr. Chairman.

Mr. ROUSH. I refer to the 19 satellites that you plan to launch this year—and it's possible that DOD would launch from 15 to 20 more satellites. What we would like you to do is to provide us with the total calendar year 1976 launch schedule, and how it would look if you were going to combine as many payloads as possible into the Shuttle system. Now, you should draw up this launch system consistent with

the payload weights, dimensions, timing requirements, orbital requirements, and DOD security requirements where combining the payloads may not be possible.

It does seem to me that this would be a rather interesting exercise, and it would be a rather practical one for us to look at as a committee.

Would you do this?

Dr. FLETCHER. We will get that information for you, Mr. Chairman.

[The information follows:]

An analysis has been made of the payloads launched in 1975 and planned for launch in 1976 to determine how they could have been combined into groupings and flown by the space transportation system (Space Shuttle and upper stages) had it been available during this period. The groupings are consistent with the payload weights, launch date, dimensions, and orbital requirements. Launch dates for schedule critical missions (ASTP, planetary, and certain DOD) were not varied. For other missions, it was assumed that the planning had been initiated to 2 to 2½ years in advance of flight permitting a launch date flexibility of ±3 months for non-DOD missions and ±1½ months for DOD. This is consistent with current practice in scheduling expendable launch vehicles.

Of the 40 civil payloads analyzed, 92 percent could have been combined with other payoads on the Shuttle. The total number of flights over the 2-year period would have been reduced from 67 expendable vehicles to the use of 38 Shuttle flights. The resulting load factors on Shuttle flights would have allowed the addition of many small payloads. The indicated efficiency of combining payloads into Shuttle flights is consistent with the 1973 Shuttle economic analysis.

GROUND RULES FOR A REPRESENTATIVE CAPTURE OF THE 1975 AND 1976 LAUNCHES

1. All payloads will be captured on the Shuttle.
2. Mixing of classified and unclassified payloads is permitted on the Shuttle—not the IUS.
3. Assume existence of two small solid propulsive stages—one of the Delta class and one of the Atlas Centaur class—to provide the velocity increment required to achieve the transfer trajectory to geosynchronous orbit.
4. IUS is available for larger high energy requirements.
5. KSC and VAFB operational.
6. Assume missions are planned 2 to 2½ years in advance of flight so that reasonable launch data flexibility can be exercised except for critical launch windows:

   The NASA missions will be scheduled within ±3 months of planned launch date.

   The DOD mission will be scheduled within ±1½ months of planned launch date.
7. Any unique DOD security requirements will be satisfied.

TRAFFIC SUMMARY COMPARISON

Shuttle flights:	1975			1976			Total		
	ETR	WTR	Total	ETR	WTR	Total	ETR	WTR	Total
Non-DOD	6	2	8	4	0	4	10	2	12
DOD/Non-DOD			2			6			8
DOD			8			10			18
Total			18			20			38
ELV flights:									
Non-DOD	14	6	20	15	4	19	29	10	39
DOD			11			17			28
Total			31			36			67

1975 CAPTURE

Flight No.: Upper stage	Payloads	Load factor	Actual launch date	Expendable launch vehicle
Flight No. 1—March:				
DSS	Landsat B	0.31	Jan. 22	Delta.
DSS	Geos-C		Apr. 9	Delta.
Flight No. 2—April:				
DSS	SMS-B	.35	Feb. 6	Delta.
DSS	Telesat C		May 7	Delta.
ACSS	Intelsat		Feb. 20	A/C.
Flight No. 3:				
	DOD			
	DOD			
Flight No. 4:				
DSS	SAS-C	.85	May 7	Scout.
2-STG IUS	DOD			
	OSO-I		June 21	Delta.
Flight No. 5—July:				
DSS	Nimbus F	.53	June 12	Delta.
DSS	COS-B		Aug 8	Delta.
Flight No. 6—Aug:				
3-Stg IUS	Viking 1	1.0	Aug. 20	TIIIE/C.
Flight No. 7—September:				
3-Stg IUS	Viking 2	1.0	Sept. 9	TIIIE/C.
Flight No. 8—July	ASTP exper	.29	July 15	Saturn IB.
Flight No. 9—August:				
DSS	Symphonie B	.35	Aug. 26	Delta.
DSS	Goes-1		Oct. 16	Delta.
ACSS	Intelsat IV		May 22	A/C.
Flight No. 10:				
DSS	AE-D	.45	Oct. 6	Delta.
DSS	DOD			
DSS	DAD(2)		Dec. 5	Scout.
Flight No. 11—October:				
DSS	AE-E	.37	Nov. 19	Delta.
DSS	RCA-A		Dec. 12	Delta.
ACSS	Intelsat IVA		Sept. 25	A/C.
Flight No. 12-18	Dedicated DOD			

Note: DSS—Delta equivalent spin stabilized solid. ACSS—Atlas/Centaur equivalent spin stabilized solid.

1976 CAPTURE

Flight No.: Upper stage	Payloads	Load factor	Planned launch date	Expendable launch vehicle
Flight No. 1—January 3-stg IUS	Helios B	0.90	Jan. 15	TIIIE/C.
Flight No. 2	DOD		Jan. 17	
Flight No. 3:				
DSS	CTS-A			Delta.
DSS	Marisat A	.72		Delta.
2-stg IUS	DOD			
Flight No. 4:				
DSS	RCA-B			Delta.
DSS	NATO IIIA	.75		Delta.
2-stg IUS	DOD			
Flight No. 5:				
DSS	Marisat B			Delta.
DSS	Indonesia A	.75		Delta.
2-stg IUS	DOD			
Flight No. 6—February:				
ACSS	Intelsat IVA-B	.39	Jan. 29	A/C.
ACSS	Comstar A		May	A/C.
Flight No. 7:				
DSS/DSS	Lageos	.51		Delta.
DSS	DOD			
	DOD			
Flight No. 8	DOD			
Flight No. 9—August:				
ACSS	Comstar B	.38	August	A/C.
DSS	NATO III B		August	Delta.
DSS	RCA-C		October	Delta.
Flight No. 10:				
2-stg IUS	DOD	.73		
DSS	Goes B			Delta.
DSS	Marisat C			Delta.
Flight No. 11—December ACSS	Intelsat IVA-C	.20	December	A/C.
Flight No. 12:				
DSS	ITOS E2	.73		Delta.
DSS	ITOS H			Delta.
DSS	Relativity			Scout.
	DOD			
Flight No. 13-20	Dedicated DOD			

Note: DSS—Delta equivalent spin stabilized solids. ACSS—Atlas/Centaur equivalent spin stabilized solids.

Mr. TALCOTT. There are always going to be modifications in developing a payload.

You know, one trouble with GAO is they are very limited in their scope. They can understand loading a truck at a station downtown and putting different loads on a truck, like furniture and lettuce. That may be possible for GAO to do. They can conjure up all kinds of problems in developing a payload. There are some problems with even a small truck on the highway, in terms of getting the right payload at the right time to the right destination. Of course, you have an enormously more complicated problem than they do. But I think you have an enormously more talended staff than the GAO has.

Dr. FLETCHER. The task is enormously more complicated, but the Shuttle flight cost will be much less than any other way of doing it.

We will be glad to do that exercise. It will be a good illustration of what can be done with the reusable Shuttle compared with the expendables.

EARLY SHUTTLE MISSIONS

Mr. ROUSH. When we looked at the 1976 calendar launch schedule, NASA, in a press release dated February 3, brags about the fact that 15 of the 19 launches will be for cash customers. Now some of those cash customers are other Government customers, such as NOAA and DOD. We looked down the list. The following are non-Government commercial satellites: The INTELSAT IV–1, the MARISAT A, RCA–B, COMSTAR 1–A, and MARISAT–B.

Now, that would be five commercial satellites in a typical launch year. If we looked at the preliminary estimate of Shuttle traffic during the 3-year period from 1980 through 1982—I know this is preliminary, but it is interesting to note when you look down that list—we don't come to a commercial satellite until the third quarter of 1982.

Why is that?

Can we assume that the normal launch rate of commercial satellites during that 2½-year period after the Shuttle becomes operational is being handled by conventional boosters?

Dr. FLETCHER. Mr. Yardley can answer that question in detail, because I happened to ask the same question just recently.

The general answer is that we don't have programs firmly identified out in 1981 and 1982. We have to estimate what the customers are going to order during that period. During 1979, 1980, 1981 and 1982, we will be having both Shuttle launches, Thor Delta launches and Atlas launches, as we make the transition. Mr. Yardley will be glad to discuss some of the details.

Mr. YARDLEY. One of the problems with that 1980 through 1982 time period is working out agreements under which we can guarantee flights; in other words making it unnecessary for them to buy a backup expendable vehicle. We are working with COMSAT right now on INTELSAT V to see if we can't arrive at an agreement where they will design the satellite so it can fly on either the Shuttle or on an Atlas Centaur. Then we will have more flexibility in making the transition to the Shuttle, and won't have to give them a 2-year leadtime in case the Shuttle were to slip because if they can't get this satellite launched, they lose dollars. This is something they don't want to risk.

However, they are committing to the satellite now. So, in 1976 they are going to make a commitment that will last through 1982. However,

we are not yet in a position to promise them a flight in 1980, as of this time.

Mr. ROUSH. Can you provide for the record what the current commercial load looks like for the calendar years 1980, 1981 and 1982?

Mr. YARDLEY. We would be happy to provide that information, Mr. Chairman.

Mr. ROUSH. And would you also provide for the record what conventional boosters would be associated with those commercial flights?

Dr. FLETCHER. We can do that, Mr. Chairman.

[The information follows:]

The time period between 1980 and 1982 is one of transition from conventional launch vehicles to shuttle operations for satellites in low and medium altitudes and low inclination. Detailed assignment of individual missions to type of launch has not been definitized. The indicated assignments are, therefore, tentative.

Our best current estimate of the non-NASA traffic (including other Government agencies, except DOD) for 1980–82 is as follows:

	1980	1981	1982
Intelsat V (Atlas-Centaur/Shuttle)	2	3	2
TDRSS (Atlas-Centaur or Delta)	4		
U.S. communications (Delta/Shuttle)		2	1
Foreign communications (Delta/Shuttle)		1	1
Aero satellite (FAA) (Delta) [1]	2		
International air traffic (Shuttle)			1
Domestic meteorological (NOAA)-(Atlas F) [1]	1	1	1
International meteorological satellite (Delta)			2

[1] U.S. Government missions.

Dr. LOW. The point Mr. Yardley was making is that, in the transition period, it is most difficult to guarantee launch schedules and the time of flight to a paying customer. Therefore, for the limited number of Shuttle flights available during the transition period, we are going to use more of those, proportionately, for ourselves, and let the paying customers, for a while, stay with the old launch vehicles. That is why you see this heavier emphasis on NASA payloads than commercial payloads in this time period.

TRANSITION TO SHUTTLE OPERATIONS

Mr. ROUSH. Let us talk about this transitional period between conventional boosters and a fully operational shuttle system.

For the past 3 years, you have told the committee that the only booster that would be retained in inventory after the Shuttle became operational was the Scout. How do you see the transition period? What boosters will we have to retain and for how long?

Dr. FLETCHER. There is a good answer to that, but it is also a long answer.

During 1980 and 1981 at least, and possibly the next year, we will be keeping in our inventory Thor Deltas and Atlas Centaurs. The Air Force will be keeping in its inventory Titan III's.

Now, exactly when our Thor Deltas and Atlas Centaurs phaseout is a subject for discussion. It might be 1981 or it might be 1982.

Of course, the Titan is not under our control. That is an Air Force program. I think we would only be guessing at this time, Mr. Chairman, to try to predict how long they plan to keep the Titans. They do

intend to have a "fly-before-you-buy" policy, so they may keep the Titans launching longer than that period.

It is also complicated by the fact that some of the launches have to be from Vandenberg Air Force Base on the west coast. Those facilities will not be operational for Shuttle launches under current plans until 1983. So you do have to keep some of the north-south or the polar orbits launched with expendable launch vehicles, at least until that date.

I can answer for NASA, that after 1982, or early 1983, we expect to be phased out of everything except Scout, and maybe even Scout. That is not sure at this point.

Mr. Yardley may want to comment on our understanding of the Air Force thinking.

Mr. YARDLEY. The Air Force is currently studying the situation, in terms of what kind of a back-up capability they need in order to protect themselves if there were a lack of funding on the Shuttle or other problems. While their studies are not complete, their present thought is that they have to be able to overlap about 2 years' worth of launches before they can really comfortably commit.

Mr. ROUSH. Would it not be advantageous to the Shuttle and its ability to make this transition period as short as possible?

Dr. FLETCHER. Yes, it would, Mr. Chairman. We will do our best to do that. There is a problem with the Vandenberg Air Force Base not being operational until 1983, and we do have some feeling of uncertainty about the availability of funding as to whether it will come in on schedule. Except for that, we are going to phase out the expendables as quickly as we can.

Mr. YARDLEY. I might add that, as far as NASA payloads are concerned, there is no thought of delaying the transition on those.

SHUTTLE ECONOMICS—DOD REQUIREMENTS

Mr. ROUSH. Thank you. Let us talk now about the DOD role in this picture.

The GAO report discusses this aspect. There has been some discussion at the staff level between this subcommittee and the Defense Subcommittee, which meets just next door, about the DOD role in the Shuttle.

Now, to refresh the memory of this committee, you will recall that the original agreement called for DOD to purchase the fourth and fifth orbiters. In addition, DOD assumes the responsibility for funding of the interim upper stage or the interim tug.

GAO STAFF STUDY ON SPACE SHUTTLE

Reading from the GAO report:

From a cost/benefit view, several studies show total costs of acquisition and recurring operations to be more than the cost of continued use of expendable vehicles for the 1980–91 period.

Then, quoting again from the report:

In the November 1975 DOD draft program memorandum, as revised, a system cost analysis of four options, using the Shuttle for the period 1980–91 indicated that in all cases, except where payload recovery and reuse were contemplated, total cost to DOD through 1991 for initial acquisition and recurring operation of the Shuttle will be more costly than continued use of expendable launch ve-

hicles. Additionally, the analysis did not include $835 million for procurement of orbiters 4 and 5. If these factors are considered, and the decision is made that DOD fund the procurement of the two orbiters, the Shuttle may not be less costly in total, even when payloads are refurbished.

Would you respond to that?

Dr. FLETCHER. I saw that quote in the GAO draft report, and I am a little puzzled as to what the GAO said and did not say. Dr. Low has also studied this in some depth, as well as John Yardley. I think we have a best guess as to what they meant. Dr. Low may want to elaborate on this.

Dr. Low. As near as I can determine, Mr. Chairman, if the GAO assumes that from 1980 to 1991 the Air Force would operate exactly in space as they are today, it would not take any advantage of the new capabilities offered by the Shuttle. Then they might as well stay with today's launch vehicles.

However, Dr. Currie and people in the Air Force—Dr. Currie is the Director of Defense for Research and Engineering—have all stated that the DOD expects to take full advantage of the new capabilities offered by the Shuttle. If they do that, there is no doubt in their minds, or in ours, that the total cost/benefit of the Shuttle, as we have discussed in previous years, will materialize. That net benefit is so large that there is a great deal of flexibility for changes.

We estimated in previous years about a $14 billion cost/benefit in terms of net benefits from the use of the Shuttle. I cannot see any way that that advantage will be wiped out.

SHUTTLE ORBITER PROCUREMENT

Mr. ROUSH. The GAO points out, and the committee has heard informally, that DOD is having serious second thoughts about purchasing the fourth and fifth Shuttle orbiters.

Now, apparently, they prefer that NASA fund the additional orbiters and that DOD be strictly a user. I suppose this decision will have to be made by the President.

The question is, how do you see it being resolved? And, more important, what would your recommendation be? Do you feel it would be more advantageous from a cost standpoint to have NASA own all five orbiters, or should DOD own these two?

Dr. FLETCHER. Mr. Chairman, you have raised the most important issue of the day, as far as those two orbiters are concerned. We do not have to face that decision in fiscal year 1977, but we do have to face it in fiscal year 1978.

I think you put your finger right on it. The President is going to have to make that decision. It really does not make too much difference to me who funds those last two orbiters, because we are all going to work together, the Defense Department and ourselves. They have diffeernt kinds of payloads, regardless of who owns what orbiters.

But it is an appreciable item of cost. The issues seem to be coming from the subcommittees that have to deal with appropriations, because neither one of them wants to approve that additional cost.

We will resolve this in time for the fiscal year 1978 budget, because we cannot let that uncertainty go on.

Mr. ROUSH. It is a DOD decision right now?

Dr. FLETCHER. We have a committee established to deal with this issue. George Low is cochairman with Mal Currie.

Dr. LOW. We, of course, recognize, as you have pointed out, that this will be a key issue in the 1978 budget discussions. Dr. Fletcher and Deputy Secretary of Defense Clemens have asked Dr. Currie and me to define within the next several months the issues that need to be resolved in order to reach an agreement, either between the Secretary of Defense and Dr. Fletcher or at the Presidential level.

Mr. ROUSH. Let me ask you, Dr. Low: Is it DOD who is pushing for NASA to provide the funds for the fourth and fifth orbiters?

Dr. LOW. At the top levels of DOD, I think they feel, as we do, that a decision needs to be made. But I do not think they are pushing in either direction.

Mr. ROUSH. How about the question even arising?

Dr. LOW. No firm decision was made in writing in the early years of Shuttle development as to which agency would fund these orbiters. We had some understandings, perhaps, with some of the people who used to be in the Defense Department 4 or 5 years ago, that it would be nice if the Defense Department would fund those two. But this was never a firm agreement between Defense and NASA, so it is still an open issue, and it was last year in GAO's report, as well as this year's draft report.

Mr. ROUSH. How about those people working on the practical level, just below the policymakers? How do they feel about it?

Why would DOD want NASA to buy the No. 4 and No. 5 orbiters?

Dr. LOW. To reduce their budget.

Dr. FLETCHER. Apparently, their congressional committees feel that maybe NASA ought to buy those orbiters instead of DOD.

Mr. MCDADE. What kind of dollar costs are we talking about?

Dr. LOW. Mr. Yardley.

Mr. YARDLEY. In 1977 dollars, we are talking about approximately $900 million.

Mr. MCDADE. Per copy or for both?

Mr. YARDLEY. Approximately $900 million for both, in the dollars of the fiscal year 1977 budget.

Mr. MCDADE. And that does not have any further requirement for any further support?

Mr. YARDLEY. There would be a certain amount of spares and such things that are associated with them, but no more facilities.

Mr. MCDADE. If you need to amplify the $900 million estimate to give me some kind of picture in 1977 dollars, I wish you would do it.

Mr. YARDLEY. We will get you the exact picture.

Mr. MCDADE. Thank you.

[The information follows:]

At the time of the Shuttle D.D.T. & E. commitment in March 1972, an estimate of $1 billion in 1971 dollars was developed for the initial Shuttle fleet investment to include the procurement of three orbiters and the refurbishment of the two orbiters bought in the D.D.T. & E. phase.

The initial assessment of the impact of the fiscal year 1977 budget reduction to defer the start of production of the third orbiter indicates a preliminary estimate of additional program cost of up to $60 million in 1971 dollars. While the fourth and fifth orbiters were not directly included in that budget reduction, it

is reasonable to assume the delay in the delivery of the third obriter would in a like manner result in similar delays in these two follow-on orbiter vehicles. If that were the case, the original fleet investment of $1 billion would be approximately $1.2 billion in 1971 dollars. Of this total, the initial estimate for the fourth and fifth orbiters would be approximately $640 million in 1971 dollars which when escalated to current dollars is $882 million in dollars of the fiscal year 1977 budget.

Mr. YARDLEY. One thing that did not come up in discussion that I would like to point out is that there is no disagreement between NASA and DOD that we need those two orbiters. Everybody agrees to that. It is really a question of how we are going to fund them.

Dr. FLETCHER. In fact, it is the other way around. We agree that this is a minimum number. There are some people in both organizations that feel that we ought to have additional orbiters, but five is the amount we settled on as a minimum that the two organizations would need.

Mr. TALCOTT. If we were having a great war to save democracy, we could easily get it in the Defense budget. But now that we are at peace, it is hard to get these things in the Defense budget.

JOINT NASA–DOD POSITION PAPER ON SHUTTLE ORBITER PROCUREMENT

Dr. LOW. I could provide for the record, if you want, Mr. Chairman, a joint NASA–DOD position statement, which first states that five orbiters are required; second, that this is not a fiscal year 1977 budget issue; and, third, that we will work out the issue for the fiscal year 1978.

Mr. ROUSH. We would like to have that for the record.

[The information follows:]

JOINT NASA/DOD POSITION STATEMENT ON SPACE SHUTTLE ORBITER PROCUREMENT

The National Aeronautics and Space Administration and the Department of Defense agree that five Space Shuttle Orbiters are needed to meet our national traffic model requirements. Three Orbiters are funded by NASA within the D.D.T. & E. and production programs. Neither agency has budgeted funds for the remaining two Orbiters. While this is a current interagency Space Shuttle issue, NASA has evolved a production plan which does not require a fiscal year funding increment. Therefore, NASA and DOD agree to work together to resolve this issue as part of the fiscal year 1978 budget cycle activities.

Date: January 23, 1976.

GEORGE M. LOW,
Deputy Administrator, National Aeronautics and Space Administration.

MALCOLM R. CURRIE,
Director of Defense Research and Engineering, Department of Defense.

INTERIM UPPER STAGE

Mr. ROUSH. Let us talk about a difference of opinion now.

Last year, on page 66 of the hearings, you testified that the cost of developing the interim upper stage would be between $40 and $100 million, with $100 million being the upper amount. The current DOD estimate is in the range of $135 to $150 million for the IUS development.

Do you have any idea why DOD is already experiencing a significant overrun on this project? Could NASA have built it cheaper?

Dr. FLETCHER. I do not think NASA could have built it cheaper, but I think Mr. Yardley has the answer to why the difference in those two figures.

Mr. YARDLEY. I just rechecked what the Air Force has in their budget, and it is $128 million in fiscal year 1974 dollars. I am not familiar with those specific numbers.

They say that this is the $100 million, plus a $28 million increase for redundant avionics. They looked at the reliability question and decided that it was better to spend that money for making it reliable to about 0.97 or 0.98 versus 0.92, because of the payload losses they could incur.

Dr. FLETCHER. By the way, we agreed with that decision.

You see, the Shuttle is so reliable that there is practically no chance of losing a payload with it. As a result, they felt they ought to make the interim upper stage much more reliable than the existing stages. So they decided to put the redundancy in, and I agree with that decision.

SPACE TUG

Mr. ROUSH. On the same subject, you have told the committee for the past 2 years that NASA still feels the reusable space tug, which would replace this IUS, is necssary.

Now, do you still feel that the space tug is an effective use of $600 to $700 million of NASA's resources?

Dr. FLETCHER. Mr. Chairman, we still feel that a fully reusable tug would pay for itself if developed. We have slipped it downstream a little bit, because of this interim upper stage which will be available. We can launch all but three of NASA's payloads contemplated during the 1980's and all of the Defense Department payloads during that period with the IUS.

Now, the question comes: Do we want to invest the $600 million? I do not know whether the number is still $600 million or if it is a lesser amount in 1971 dollars. Do we want to invest that $600 million in order to get the additional savings from both the payloads that you would recover, plus the reusability of the tug?

At the present time, for planning purposes, we still intend to go ahead with the tug program definition in fiscal year 1979.

Mr. YARDLEY. Then 1985 would be the earliest operational date.

Mr. ROUSH. And when would you request your initial funding?

Mr. YARDLEY. In the fiscal year 1979 budget, based on current planning.

Dr. LOW. There is no money in the fiscal year 1977 budget request for the tug.

Mr. ROUSH. Nor do you contemplate any money in the fiscal 1978 budget; is that correct?

Dr. FLETCHER. That is correct, based on our current planning.

TUG COSTS

Mr. ROUSH. The GAO also raises the same question and asks what NASA's justification is for continuing the planning and development of the space tug when few satellites are projected to be recovered from high Earth orbits, and the DOD selection of a solid propellant

interim upper stage is expected to have a comparatively low operating cost.

How much have you spent on the tug? Any at all in fiscal year 1976?

Dr. FLETCHER. Some study money was spent on the tug, and I don't have the exact amounts, but we can furnish that information, Mr. Chairman.

[The information follows:]

Since fiscal year 1975, NASA has funded approximately $1.5 million of direct Tug studies. Of that amount, $500,000 has been spent in fiscal year 1976 to conclude efforts started in fiscal year 1975.

Prior to fiscal year 1975, however, advanced studies of propulsive upper stage concepts were conducted.

Mr. ROUSH. Is there any study money in the fiscal year 1977 budget for the tug?

Mr. YARDLEY. No, sir.

SPACE SHUTTLE—SAFETY RATING LEVEL

Mr. ROUSH. Again, informally from the Defense Subcommittee staff, we have learned that some DOD satellites could be substantially reduced in cost if NASA would be willing to drop the man rating safety level of the Shuttle.

Are you familar with this question; and could you expand on it?

Dr. LOW. We have engaged in joint studies with the Department of Defense on the transition cost of their payloads to be accepted by the Shuttle, and there were three cases of concern. One had to do with the noise environment in the Shuttle payload bay itself; the second had to do with the loads, the forces on the payload during the launch; and the third is the so-called ditching load. If the Shuttle should have to be aborted or ditched in the ocean, what would it take to tie the DOD payload down so that it would not tear loose and break up the Shuttle?

When the Department of Defense first looked at these things, it looked as though there would be significant costs associated with those three items.

When we studied these things in more detail in conjunction with the Department of Defense, it turned out that all those problems would yield to engineering analysis and solutions, and, to my knowledge, there would be no additional charges on DOD payloads for safety.

There is old information on this subject in the GAO report that is no longer pertinent.

SPACE SHUTTLE SCHEDULE

Mr. ROUSH. One of the major points made by the GAO report is the extremely tight schedule margins that allow for little or no technical or other unforeseen problems. This concern is also supported by a team, headed by Mr. Willis Hawkins of Lockheed Aircraft, which concluded there is very little margin available in the event of unforeseen problems.

Also, the GAO report indicates that NASA's Space Shuttle program office supports Mr. Hawkins' point in that your own analysis shows that unless the schedules can be improved, the first manned orbital flight will slip beyond the current target date of March 1979.

What is your response to that?

Dr. Low. Mr. Chairman, first of all, the Hawkins team main statement was that the Space Shuttle program was accurately projected, well managed, and one of the best conceived programs that they have ever seen. The Hawkins team went on to say, in part of their report, that they are concerned that this is a tight development program, just as every other space program that has ever existed.

The GAO picked up that particular language.

The important thing is that there has been a great deal of learning in the space business since Mercury and Gemini and Apollo, and the teams that are working on these programs today are a great deal more experienced than any teams we have had working in the past.

We have some examples. A critical test, in my judgment is the first time you run a check of the wiring system in the Space Shuttle or any other spacecraft. This is very complicated wiring with thousands of wires. It turned out that the first test of the wiring system on the first Space Shuttle orbiter found fewer errors, and was a better test by far than the final test on the last Apollo spacecraft.

In other words, the team that is building the Shuttle, by this indicator and by many others, is enormously experienced compared to what we have done in the past. We have the advantage of past learning.

Now, even though they are working on a tight schedule, from my own observations I have every confidence that the team is going to bring the Shuttle in within the schedule.

SPACE SHUTTLE TEST REQUIREMENTS

Mr. Roush. The GAO report also points out that NASA has deleted or reduced certain tests to remain within budget constraints and to relieve schedule pressures.

Now, of course, we won't know for some time whether the current testing philosophy is cost effective, but, obviously, you must believe—and you have indicated by the answer you just gave—that you can cut some corners in that area and still meet the schedule; and you can do so because of the competence that has been developed over the years.

Dr. Low. I don't think we are cutting corners, Mr. Chairman.

COST CONSCIOUSNESS ON SHUTTLE

Mr. Roush. What are you doing?

Dr. Low. The most severe criticism in the GAO report is that we are terribly cost conscious. That is the kind of criticism I like. We are certainly concerned about costs in the development of the Shuttle. The Space Shuttle team did propose to cut out certain tests primarily to relieve cost pressures in early fiscal years. That was proposed by the team in Houston and by the contractor team.

It was reviewed by the Space Shuttle program office in Washington. Mr. Yardley. Dr. Fletcher and I personally reviewed the recommendations, and it was our best judgment that this was a good thing to do. We have seen nothing since then—and this was done more than a year ago—to say that this was a bad move.

Mr. Talcott. I got the impression from the GAO report that in the early days of the program, mission accomplishment was the key objective. This was in the 1960's.

Now, with the Space Shuttle program, there is more cost consciousness. We are even more concerned about getting our dollar's worth. I think that is a really admirable objective.

When we had the crash program, we probably did waste some money. Also, when we had the Apollo-Soyuz mission, I don't think we were as concerned about cost in that as having a pretty effective publicity stunt. And I think paying attention to cost is a good idea. And so I'm not sure the GAO report is as critical as you make it out in that respect.

Dr. Low. I must have misunderstood. I am proud of the fact that GAO is saying that we are cost conscious, because I believe that we are and we should be.

Mr. Talcott. I think GAO is worried that because of fiscal constraints, because of some deferrals when any other project, any other Federal program has tight fiscal constraints put on, that they do take some chances, and that the development is not as perfect as it would be. This is what they are worried about.

Dr. Fletcher. I think they are worried. And I guess from their vantage point, properly worried; however, they don't know the highly competent and experienced Shuttle team.

I am a relative newcomer to the program. I have been here less than 5 years. But I know that this team does know how to put a vehicle of this sort together. I soon developed the confidence that they could, and I never would have made the commitment to the original Shuttle development cost of $5.150 billion in 1971 dollars—three decimal places on the cost of the development of this Shuttle, if I did not have complete confidence in this team. They know what to do and how to do it well. Although I personally was concerned when they proposed to delete or reduce some of these early tests, when I carefully reviewed the subject, I was completely convinced that these people knew what they were doing.

Nowhere that I know of—and Dr. Low and Mr. Yardley and myself all went into this in depth—did they make any changes that would have jeopardized the safety of the mission.

The only places where they shaved tests or cut out tests were places where they had developed confidence from the Apollo program and from their other early simulations and calculations that those tests really were redundant and not necessary.

Now, any large-scale, complex R. & D. development effort is a very unusual program, and that is the part that I don't think the GAO can fully appreciate, because they are not as close to it as we are. We reviewed the subject in great depth, and concluded that the changes in no way compromised safety.

SHUTTLE MAIN ENGINE TESTING

Mr. Roush. We understand that recently there was an accident at Santa Susana in connection with the testing of the main engine.

Could you describe that? Could you tell us how far back that has set the schedule?

Dr. Fletcher. Mr. Yardley?

Mr. Yardley. About a week ago last Wednesday, we were running a test on the high pressure oxygen pump itself. This is one of the big

turbo pumps to feed propellants. We were not testing a complete main engine.

The test set-up simulates the rest of an engine. There are large liquid oxygen tanks feeding it. A device downstream from the pump, which was part of the ground support equipment, failed.

A couple of pins came loose and broke the blades on a flow meter, which went on down and struck an orifice which started a fire, and it damaged part of the test stand.

About half of the pump will have to be replaced, and the test stand will have to be repaired. We estimate that it will take about 8 weeks to repair that station of the test stand at Santa Susana, and the adjacent station, about 6 weeks. The other test stand at Santa Susana will not be affected at all.

This incident at Santa Susana has not affected our testing at Mississippi, where we have two engines and two test stands. We don't anticipate any major impact on the main engine project milestones.

Dr. LOW. When are you going to run it again?

Mr. YARDLEY. Tomorrow.

Dr. LOW. I think that's the key answer. We'll run another test on that engine tomorrow.

CONTINGENCY RESERVES

Mr. ROUSH. What about the contingency reserves for the Shuttle? You may not want to talk about specific dollar amounts, but could we discuss it in terms of a percentage of the reserves that have already been committed.

Dr. FLETCHER. We are very cautious about the contingency, because we are trying to manage this program very carefully; and part of that management is careful, judicious use of that contingency fund.

Mr. LILLY. The number that GAO included in their report—I believe they said something like 55 percent of the contingency funds had been used.

This is not correct. The amount that has actually been spent out of contingencies at this time is about 8 percent. The amount that we have identified for use, the amount that we have reserved as contingency for anticipated requirements is approximately 45 percent of the total. That leaves us a balance of approximately 55 percent of our contingency for unforeseen difficulties that may occur in the future.

This amount, in our judgment, and all the tests we have done on it, is fully enough to carry out the program.

When I question people on the GAO report in terms of where did the GAO staff come up with other programs historically needing more, I received answers such as large construction programs, dams and things of this nature. I don't think we are comparable to that kind of an effort.

Mr. MCDADE. I hope not.

Mr. LILLY. I think we have demonstrated that we can do it. We have adequate reserves in the program and we will carry it out.

Mr. ROUSH. I gather you do feel comfortable?

Mr. LILLY. Yes; we do.

Mr. TALCOTT. You have not obligated 55 percent of your reserves?

Mr. LILLY. No, sir, we have not.

Dr. FLETCHER. Mr. Chairman, if you really want to delve into that, I would be willing to do that in a private discussion. If you are really

concerned about that item, we could discuss it with you, and it would perhaps make you feel more comfortable about it.

SHUTTLE ORBITER PROCUREMENT WESTERN TEST RANGE FACILITIES

Mr. ROUSH. We will let the chairman of the subcommittee make that decision.

As you know the GAO suggested that the Congress look at the possibility of delaying the funding for orbiter production and western test range facilities until the benefits of the shuttle system can be substantiated.

They indicate that this approach would be consistent with the "fly-before-buying" concept now in use in DOD. I think I have heard Mr. Mahon, the chairman of our House Appropriations Committee, use that term quite frequently.

OMB has relieved the Congress of having to make that decision in fiscal year 1977. As I understand it, there are no funds in the fiscal year 1977 budget for the production of the third orbiter; is that correct?

Dr. FLETCHER. That is correct, Mr. Chairman.

Mr. ROUSH. The point is that before we make that decision, we want to make sure we are not funding a white elephant. That is why we have been asking all of these questions. I know that the Shuttle has many other potential uses. It could be revolutionary in the field of materials processing. It could change the whole biological and medical processing horizons. But the fact is that the Shuttle was sold to the Congress primarily as a space transportation system, substituting for the conventional expendable boosters. Next year, this committee will have to make a decision not only to fund a third orbiter, which is the first production vehicle, but quite possibly, also, to initiate funding for the fourth and fifth orbiters. Before we make that decision, we want to make sure we are on the right track. And within the next 9 months, the committee may have its investigative staff look into some of the problems we have been talking about here today. And I assume they will receive your full cooperation.

Dr. FLETCHER. We will be glad to cooperate, Mr. Chairman.

NASA-GAO RELATIONSHIP

Mr. BOLAND. Thank you very much, Mr. Roush; and thank you for your responses.

I get the feeling, and so does Mr. Shipley, that you don't pay much attention to GAO reports, anyhow.

Dr. FLETCHER. We take the GAO reports very seriously, but they are not as close to the program as we are, and occasionally they do make some mistakes.

But we do pay attention to what they say, and we pay attention to what this committee says.

Mr. SHIPLEY. Let me say that it has not been evident by the response on the comments of GAO today. I don't recall anyone on that side of the table saying that GAO was once right in any of their statements.

Mr. LILLY. Mr. Shipley, I think they are right when they say that we are very cost conscious.

NASA RECORD ON STAYING WITHIN COST ESTIMATES

Mr. BOLAND. Actually, when you look at the record of NASA, it has been a magnificent record with respect to staying within costs on particular programs, and there is no doubt about the fact that your entire staff gives considerable attention and concern to this matter. I guess it can be said that few agencies really have come closer to targets on particular operations and activities than NASA has. At least that has been the experience that this subcommittee would glean from hearings with NASA.

Mr. TALCOTT. And I think it is true, Mr. Shipley, that we went through the GAO report and picked out the criticisms of NASA that were there. It is not all critical of NASA. I think we ought to remember the GAO, in my judgment, is a group of accountants. They are bookkeepers. They are arithmeticians. They are accountants. And they really don't have a sensitivity or appreciation for the particular group that they are dealing with.

Dr. FLETCHER. Mr. Talcott, I don't want to prolong this about the GAO, but I think Mr. Shipley made a statement which I would like to comment on. He indicated that we don't pay any attention, or we don't agree with anything in the GAO report.

Mr. SHIPLEY. Unless it's good.

Dr. FLETCHER. We do have to address the points where we disagree, and we discuss these issues with GAO.

We can make a much longer list of parts where we agree with their report. I think that GAO certainly does perform a service in making us account for all of these dollars, which we do and we will be glad to furnish any of this for the record.

And we do agree with a large number of things that they put together in reports.

PUBLIC VIEWS ON SPACE PROGRAM

Mr. TALCOTT. In terms of the poll that we talked about earlier, where 55 percent of the people agreed that space programs could be cut, I would like to see a survey on the Congress. I bet 95 percent of the people think that Congress could cut its budget.

NEED FOR BETTER PUBLIC UNDERSTANDING

Mr. BOLAND. The trouble is, I do not know whether you have been able to sell the program too well. You know, the Space Shuttle does not have any particular appeal to people. You could send Joe Allen out there to most areas, and with that boyish look and the fact that he is an astronaut, he could probably sell it. But you keep him here in Washington, and he loses his effectiveness. The Space Shuttle is the big mission of NASA now. It was a decision that was made by the administration and by the Congress to go ahead with it, and as has been indicated here, it is very costly. It is an awful lot of money. And

those of us who have some responsibility for the program, because we happen to sit on this subcommittee, do not always sense the public's acceptance of this.

It was kind of difficult to sell it to the OMB. Your budgets over the last years have been cut by OMB. In fiscal year 1975, OMB cut your Space Shuttle budget by $89 million, causing an increase in the development cost estimate of $50 million. In fiscal year 1976, they cut the Shuttle budget by $45 million, and in terms of the fiscal year 1977 Shuttle budget, they cut it by $100 million.

So, you have difficulty even selling it to OMB, which makes it a bit more difficult to sell, I suppose, to the public.

Mr. TALCOTT. The point that the chairman is making is a very good point. If you had as many people as HEW has around in the country selling their programs—even a small proportion of them—I think you could double your budget.

Dr. FLETCHER. I think, Mr. Chairman, that criticism is valid, and I guess I do not really have a defense except to say that engineers are perhaps not as good as other people at selling their programs. We stick to our job, and watch pennies, and we do not communicate to the public adequately.

ECONOMIC BENEFITS FROM NASA PROGRAMS

Mr. BOLAND. I know you discussed in your statement, at length, the relationship of productivity and advanced technology. I am sure that all of us on this subcommittee have been impressed by the positive effect of NASA-type high technology expenditures. High technology projects have the advantages of being less inflationary in the short run and more beneficial to the economy in the long run. Closely tied to that statement is the point you make that there is no way in the long run that our economy can grow with unemployment reduced and inflation held in check except by increasing productivity. And increases in productivity depend on developing advanced technology.

I know we have talked about this, and I know Mr. Roush has. I think that is a terribly important statement, and I think that you have justified your position on it. We have talked about some of the spin-offs, and you use another expression, and you mentioned a few. We hope that you will—and perhaps Mr. Roush has already asked you to—expand for the record on some of the advances that NASA has made over the past few years. All I have been hearing about is the development of the fire-resistant clothes. I do not want to hear about that. I have heard about it three or four times now.

We want to hear about something that is a little bit different. You can put that in too—but nevertheless, we would hope you would expand for the record the usefulness of the space program with respect to everyday, ongoing problems that the Nation and people—consumers—might have.

Dr. FLETCHER. We will be happy to do that, Mr. Chairman.

[The information follows:]

SPACE BENEFITS

These benefit cases have been prepared for the NASA Technology Utilization Office by the Denver Research Institute, "Program for Transfer Research and Impact Studies," to provide the Agency with accurate, convenient, and integrated resource information on the transfer of aerospace technology to other sectors of the U.S. economy.

MANUFACTURING CONSUMER PRODUCTS

Infrared scanner and television display: operational unit developed for Marshall. . . . commercial infrared TV scanner developed. . . . product purchased by B.F. Goodrich Co. (Ohio) and regularly used for consumer product R&D. . . . applications include analyzing tire designs and causes of tire fatigue, identifying tire design and construction flaws, and investigating how heat shortens service life for V-belts, shock mounts, brakes and rubber bearings. . . . scanner enables researchers to observe and record heat build-up during product testing so designs or production processes can be improved. . . . 1973 R&D funding by rubber products industry was about $200 million (1.1% of sales), large part directed toward product improvement.

Management method for R&D programs: developed for Marshall. . . . used by The Upjohn Co. (Michigan) to develop management method for its pharmaceutical research programs. . . . saved Upjohn substantial man-hours.

Composite materials data: compiled for Marshall. . . . used by Babcock and Wilcox Co. (Ohio) in designing composite products. . . . orders of nearly $1 million in 1973. . . . products used in golf club shafts and business machines.

Multiplexer circuit for Saturn rocket instrumentation: developed for Marshall by SCI Systems, Inc. (Alabama). . . . integral part of industrial monitoring system developed by SCI. . . . entire industrial system similar to Saturn instrument monitoring system. . . . SCI system installed in most U.S. textile weaving mills built between 1968 and 1971, 17 installations by SCI in price range $65,000 to $100,000, at least 4 more installed by ex-SCI employees working for West Point-Pepperell, Inc. (Georgia). . . . product line sold to Swiss company in 1971, with same technology used in many new textile weaving mills worldwide (particularly, Poland, France, Belgium and U.S.). . . . system monitors loom operator performance and is wholly responsible for productivity increases over 1%, generally in 2-6% range. . . . annual national productivity increase was 1.7% between 1967 and 1970, 3% before and after that time period.

Contamination control handbook: compiled for Marshall. . . . used by Ortho Pharmaceutical Co. (New Jersey) to design better contamination control facilities for birth control pill production. . . . increased worker productivity . . . . used by Kentucky Electronics, Inc. (Kentucky) to improve two key production steps for consumer electronics (mainly color television components for RCA, Westinghouse and Zenith products), degreasing and drying operations now done with fluids and processes described in handbook. . . . improved product quality and productivity, with annual sales over $7 million.

Method to improve electrical resistors with hydrogen: developed for Headquarters. . . . used by Zeller Corp. (Ohio) to develop automated process for resistor spark plug production. . . . automation saves 4 cents per unit and over 500,000 sold annually since 1972.

Optical alignment training manual: compiled by Marshall. . . . incorporated into standard operating procedures at Eastman Kodak Co. (New York) for aligning optical testing instruments. . . . accuracy improved.

Intumescent fire retardant coatings: developed by Ames. . . . used, under NASA license, by Avco Corp. (Massachusetts) to develop commercial product line. . . . more than 50,000 sq. ft. of the intumescent sheeting product sold monthly to major manufacturer of hoses. . . . used as protective cover on fuel hoses for inboard pleasure boats. . . . Avco working with Boating Industry Association and U.S. Coast Guard to develop additional intumescent coatings for pleasure boat applications such as fuel tanks and engine compartment walls. . . . improved fire safety for boating.

Dry lubricant coating processes for metals: research need identified in quality control study conducted for Headquarters by General Magnaplate Corp. (New Jersey). . . . company developed and patented 4 processes to bond dry lubricants, such as Du Pont's Teflon, on metal surfaces for space applications . . . . many components for Apollo, Viking, Skylab, and Shuttle coated by General Magnaplate. . . . commercial coating services introduced; annual sales are $1.8 million. . . . over 600 manufacturing clients include GE, IBM, RCA, Westinghouse, Polaroid, and ITT. . . . applications include production equipment for hundreds of household items such as molded plastic products, dog biscuits, birth control pills, and food, as well as products such as computer components, office equipment, packaging machinery, turbines, valves and racing car components. . . . coated production equipment enables longer wear life, higher operating speeds, and cleaner operation. . . . increases productivity and lowers unit cost. . . . two Japanese companies, including Mitsubishi Corp., and one Israeli company licensed to use processes.

MANUFACTURING CAPITAL GOODS

Microelectronics production quality assurance: NASA established reliability program and procurement standards for microelectronic products in 1964 to assure best manufacturing practices would be used by suppliers. . . . introduced concept of Certified Production Line (CPL) so that entire production lines, rather than products themselves, were certified for NASA procurement after vendor had established quality control practices and in-house evaluation methods to satisfy NASA inspection teams. . . . CPL approach later adopted by DOD which developed, with NASA, certification standards. . . . many major microelectronics manufacturers configured standard production lines to be certified for space or defense procurement and now produce commercial units from these lines. . . . widespread impact by increasing productivity for commercial products on world market. . . . one vendor increased yield by 20% after modifying production practices for certification (1-2% increases very valuable in the industry). . . . Marshall obtained one of first scanning electron microscopes (SEM) ever built and developed SEM inspection techniques to analyze failure modes for microelectronics. . . . provided failure analysis reports to microelectronic vendors and encouraged manufacturers to use SEM for same purpose. . . . SEM's now widely used in U.S. microelectron-

ics industry. . . . largest producer of microelectronics, Texas Instruments (Texas), with annual sales over $1 billion, is certified by NASA and used 3 SEM's for quality assurance and failure analysis. . . . NASA standards used in key production steps for all TI products.

Infrared scanner and television display: operational unit developed for Marshall. . . . contractor employees founded Dynarad, Inc. (Massachusetts) to market unique product line of IR scanners. . . . units display heat picture on TV screen. . . . over $2 million in total sales, unit price range $6,500 to $25,000. . . . customer applications include maintenance inspections, quality control, and research in several industries (steel, aluminum, petrochemical, rubber, nuclear fuels, aircraft and electric power) as well as medical diagnoses such as breast cancer.

Ultrasonic nondestructive testing techniques: developed for Marshall and Johnson by Automation Industries, Inc. (Connecticut). . . . company had over $2 million in contracts to produce innovative NASA equipment in past few years and has "had commercial spin-offs of several times that amount". . . . for example, Marshall funded the development of company's laboratory prototype into operational ultrasonic Delta Manipulator which Automation then marketed . . . . uses multiple transducers for significant improvement in speed and accuracy. . . . more than 25 manufacturers purchased between 1 and 100 Manipulators @ $800. . . . larger number of firms fabricated in-house versions. . . . widely used for quality control inspection of aircraft components and steel pipe manufactured for petrochemical applications. . . . Automation has $50 million annual sales of ultrasonic test equipment for quality control in steel, railroad, aircraft, nuclear reactor, automotive, and tubular products industries.

Fracture toughness tests: developed by Lewis. . . . used by Aluminum Company of America (Pennsylvania) to provide fracture toughness guarantee for high-strength alloy products. . . . critical design parameter for Alcoa customers who use these alloys to fabricate aircraft components, chemical processing equipment, or liquefied natural gas containers on ocean tankers. . . . reduces structural failures.

Thermal expansion properties handbook: compiled for Marshall. . . . used extensively at Eastman Kodak Co. chemical plant (Tennessee) in design and materials selection for new hydrogen production facility worth over $500,000 . . . . saved 25% of design cost and significant amount of construction cost . . . . also used to select better materials for catalytic cracker and heat exchanger.

Mass flowmeters for low gas flow: developed to meet specifications of Johnson Apollo subcontractor by Tylan Corp. (California). . . . Tylan introduced gas flowmeter as commercial product in 1968. . . . product now used extensively in U.S., Europe, and Japan for process control and manufacture of semiconductors, as well as in petrochemical production, medical instrumentation, heat transfer devices and thermodynamic analysis. . . . since initial NASA market in 1965, growth in annual sales from $300,000 to $3,000,000, employment up from 20 to 80. . . . entire business based on fallout from Apollo Program.

NEW CONSUMER PRODUCTS AND RETAILING

Heat pipe technology: developed for NASA by Los Alamos Scientific Labs and others. . . . based on availability of NASA R&D results from a Regional Dissemination Center, Isothermics, Inc. (New Jersey) was formed in 1971 to market heat pipe products. . . . five product lines introduced and successful . . . . $700,000 sales in 1972, over $1.5 million sales in 1974. . . . over half of sales are for Air-O-Space and Thermo-Coil, heat pipes that recover waste heat from furnace flue gas. . . . Air-O-Space for home furnaces, 10,000 sold in 1974 @ $100. . . . Thermo-Coil for industrial furnaces, dryers, etc., just introduced, projected annual market doubling and $2 million sales in 1976. . . . products increase heat efficiency by 8-10%, relevant to new consumer demand. . . . Isothermics capturing large market share early in trend toward energy conservation equipment.

Anti-fog compound: developed for Johnson. . . . prevents condensation fogging on transparent surfaces. . . . more than 60 NASA licenses issued. . . . sold by Western Fire Equipment Co. (California) for fire fighters' face shields, air masks and for protective goggles. . . . marketed by others for eyeglasses, diver's masks, ski goggles. . . . known sales exceed $500,000.

Rogallo airfoil design: developed by Langley Research Center for rocket recovery. . . . used by Free Flight Systems (California) and others to design hang gliders for recreational use. . . . Rogallo design used on 90% of all hang gliders. . . . Free Flight Systems is largest manufacturer of hang gliders. . . . 3,000 sold @ $500. . . . rapidly growing sport.

Battery-powered hand tools: developed for Johnson by Black and Decker (Maryland). . . . commercialized by B & D into line of 6 cordless power tools for home consumer (including 1/4" drill, 3 models of grass shears, 2 shrub and hedge trimmers). . . . direct improvement over previous line. . . . sales figures not available.

Aluminized mylar: basic patent by National Research Corp. in 1962. . . . first applications developed for Lewis (Echo I, spacecraft, space suits) . . . . commercial product, SPACE blanket, introduced by NRC in 1964. . . . NRC became Norton Co. division and metallized process extended to provide fabric coating service for companies, such as McGregor-Doniger, Inc. (New York), making ski parkas, coats, sleeping bags, life raft canopy. . . . annual sales for Norton coating service and products over $2 million. . . . division sold to King-Seeley Thermos Co. (Massachusetts) in 1971. . . . products and process still being marketed, sales figures not available.

Apollo Guidance Computer software and Data communication methods: developed for Johnson by TRW Systems (California). . . . used by TRW Data Systems (California) to develop computerized retail sales systems for department store chains. . . . largest supplier of such systems; has installed about 60 on-line computer systems (80% of total installations), with over 50,000 point of sale (POS) terminals connected to these systems. . . . typical system with 1,000 credit authorization terminals in 175 stores costs about $1.5 million; average improvements over nonautomated methods include 95% reduction in purchases on bad debt accounts, 75% reduction in fraud purchases, 20% cost savings in pay-

roll for authorization employees, and 33% reduction in telephone calls. . . . systems with POS cash register terminals also provide improved inventory control, more accurate and faster sales transactions, more detailed merchandising information, and better sales data for management analysis. . . . TRW customers include Montgomery Wards, May Co., Neiman-Marcus, J.C. Penney, Rich's, Burdine's, Hudson's Bay Co., and many more.

Polyurethane-silicone plastic foam: developed for Ames Integral Passenger Aircraft Seat Program. . . . produced commercially as TEMPER FOAM by former contractor employee. . . . used by Becton Dickinson and Co., Protective Products Div. (Texas) as padding in football helmet products. . . . compared to conventional helmet padding, reduces shock from impact by 340%. . . . since market introduction in October 1974, approximately 2,000 helmets sold @ about $20 each. . . . sales mostly to school teams; also purchased by Dallas Cowboys.

Quartz crystal oscillator for Apollo Central Timing Equipment: developed for Johnson contractor by General Time Corp. (Illinois). . . . provided stable primary time base and related integrated circuits for all Apollo mission timing functions. . . . GT used the revolutionary new timekeeping base, now called Quartzmatic, and integrated circuits to develop line of consumer clocks and watches. . . . maintain accuracy to within 1 minute per year. . . . produced by GT Westclox and Seth Thomas Divisions in retail price range of under $30 to over $250. . . . popular new consumer product.

Highly reliable flashlight switch: developed for Langley by ACR Electronics; now Chromalloy American Corp., Chromalloy Electronics Div. (Florida). . . . used in all manned spacecraft. . . . repackaged and introduced by Chromalloy as consumer flashlight, "5 Year Light". . . . long shelf-life guarantee possible because switch will not corrode and cause battery drain. . . . typically stored for emergency use. . . . over 2 million units sold @ $6 to $7 each.

ELECTRIC UTILITIES

Combustion analysis computer programs: developed by Lewis and for Johnson . . . . used since 1970 by former space program combustion experts, KVB Engineering, Inc. (California), to design firing modifications for power plant fossil-fueled boilers. . . . reduced nitrogen oxide emissions by 40-70% in compliance with legal standards. . . . KVB has analyzed emissions from 160 large boilers, 100 small boilers and 30 ground power gas turbines . . . . over 100 large boilers modified for utilities nationwide, e.g., Southern California Edison Co., Los Angeles City Department of Water and Power, Consolidated Edison (New York), and Houston Lighting and Power Co. . . . . pollution reductions by KVB method considerably less expensive than by any known alternative; little or no added operating costs.

Combustion analysis computer program: developed by Lewis. . . . used by Babcock and Wilcox Co. (Ohio) to modify utility boiler product designs for reduced nitrogen oxide emissions and to develop new sulfur dioxide removal system for power plant stack gases. . . . unique capability to analyze operating trends for experimental hardware, a guide in design improvements.

Apollo Guidance Computer software: developed for Johnson. . . . used by TRW Controls (Texas) to develop TRW Executive Program and other software for electric power dispatch computers. . . . provides real-time control capability in large, multi-tiered computer systems installed at General Public Utilities Corp. (Pennsylvania and New Jersey) and Arkansas Power and Light ($500,000 installation). . . . also being installed at Public Service Co. of Oklahoma and Swedish State Power Board. . . . Apollo software also used by TRW Industrial Operations (California) to provide real-time control capability in new Bonneville Power Administration (Washington) dispatch computer system ($5.2 million installation). . . . benefits cited by BPA include decreased blackouts and $400,000 annual transmission savings . . . . TRW is second largest producer of dispatch computer systems in U.S.

Digital color television display: developed for Johnson Mission Control Center by Philco-Ford (Texas). . . . P-F developed commercial product for electric utility dispatch computer control center. . . . DCTV display installed at Cleveland Electric Illuminating Co. (Ohio), Houston Lighting and Power Co. (Texas) and Pennsylvania-New Jersey-Maryland power pool control centers. . . . product line sold to North American Rockwell Information Systems Co., NARISCO, (California). . . . installed at Philadelphia Electric Co. (Pennsylvania) as part of dispatch computer system developed by NARISCO . . . . DCTV provides operator/dispatch computer interface with greater accuracy, shorter response time, and more versatility, which decrease the chance of another major blackout.

Fracture toughness tests (and analytic methods): developed by Lewis. . . . included in ASME Boiler and Pressure Vessel Code for nulcear power plant components. . . . used by major manufacturers to design nuclear plant equipment and steam turbines. . . . users include Westinghouse (Pennsylvania), General Electric (New York), Babcock and Wilcox (Ohio), Atomics International (California), General Atomic (California) and Combustion Engineering (Tennessee) . . . . annual capital investment in nuclear power was $3.5 billion in 1972 and 1973. . . . trend toward larger nuclear plant designs (200 Mw in 1965, 500 Mw in 1969, and 1,000 Mw in 1974).

Fatigue analysis methods: developed by Lewis. . . . included in ASME Elevated Temperature Design Code. . . . used by General Electric Co. (New York) for steam turbine design, Westinghouse (Pennsylvania) for steam turbine maintenance, General Atomic Co. (California) for high temperature gas-cooled reactor design, Combustion Engineering, Inc. (Tennessee) and Babcock and Wilcox Co. (Ohio) for electric power steam generator design. . . . provides better prediction of fatigue life from high temperature test data.

Apollo Program quality assurance specifications: (NPC 200-2) developed by Headquarters. . . . modified by DOD for military specs (MILQ 9858A) which in turn were largely incorporated by AEC (District of Columbia) in comprehensive quality assurance specs for nuclear plant licensing. . . . General Electric Co. (Florida) implemented Apollo specs under NASA contract, now offers Nuclear Quality Assurance Consulting Service to do same service for electric utilities with similar AEC specs. . . . four utilities and five nuclear plant contractors have used GE service on 12 nuclear plants, including Commonwealth Edison Co. (Illinois), Florida Power Co., and TVA (Tennessee) . . . . Ontario Hydro (Canada), third largest electric utility in North America, 15,000-Mw capacity, is using NASA specs to develop own QA specs for contractors.

ENVIRONMENTAL QUALITY

Skylab carbon monoxide monitor: developed for Ames. . . . commercialized by Andros, Inc. (California) as air pollution monitor. . . . now sold by Beckman Instruments (California). . . . unique design features allow accuracy and portability. . . . instrument certified by EPA. . . . over 30 sold @ $6,800 to air pollution agencies and companies. . . . used to measure carbon monoxide pollution in urban areas, such as the CO profile over Los Angeles.

Hazardous gas analyzer for Saturn rocket: developed for Marshall. . . . adapted by Chrysler Corp. (Alabama) to develop product line of vehicle exhaust analyzers. . . . over 70 large units sold @ $15,000-$50,000. . . . provides simultaneous measure of CO, CO_2 and hydrocarbons. . . . allows automated testing. . . . analyzer accepted as legal alternative standard by EPA and California for vehicle emission certification testing. . . . used by Chrysler (Michigan) for new vehicle certification (heavy duty engines) and quality control during production. . . . used by Chrysler (California) for 2% Quality Audit of new cars, a California requirement (3,000 cars/year, $600,000 test facilities). . . . also used to trouble-shoot defective vehicles, reducing labor costs at least 50%. . . . Chrysler's portable exhaust analyzer product used for state inspection by garages and car dealers. . . . over 1,000 small units sold @ $1,600.

Filter cassette for sampling particulate pollutants: designed and produced for Lewis air pollution program in Cleveland by General Metal Works, Inc. (Ohio). . . . commercialized by contractor. . . . $25 cassette widely sold for pollution monitoring stations. . . . considered by pollution experts to be best cassette on market. . . . prevents sample contamination during transport to and from monitoring stations.

Satellite telemetry systems: developed for Goddard by General Electric Co. (Pennsylvania) for Nimbus and ERTS-1. . . . used by GE to develop state-wide computerized air pollution monitoring network (COPAMS) for Pennsylvania . . . . 32 stations to implement air quality laws.

Weather satellite data: program managed by Goddard. . . . used by National Weather Service (Maryland) to forecast wind conditions. . . . forecasting used by state air pollution agencies (Colorado and others) for air stagnation maps and air pollution dispersal conditions. . . . dispersal prediction crucial for implementing pollution control sequence (advisory, alert, warning, emergency).

ERTS-1 imagery: program under Goddard supervision. . . . imagery used by scientists at University of Vermont to identify and map major pollution plume in Lake Champlain caused by paper mill. . . . partial basis for legal action by State of Vermont against paper mill and State of New York. . . . ERTS imagery and interpretation of imagery accepted as legal evidence in case after review by Supreme Court-appointed master. . . . one of first pollution cases involving state vs. state accepted by Supreme Court.

Precipitation-hardened steel alloy: developed for Johnson (Apollo Command Module) by Armco Steel. . . . Armco alloy used by Hopper, Inc. (California) in fabricating Ram-Jet, wind machine for frost protection in noncitrus orchards (apples, almonds, etc.). . . . @ $7,000. . . . several hundred operating in Washington, Oregon and California.

Contamination control handbook: compiled for Marshall. . . . used at USDA Research Center (Louisiana) for training employees and research. . . . recommended by USDA to food processing firms with contamination problems. . . . one research application was developing a process for converting cottonseed pulp to high protein (67%) flour for human consumption. . . . due to contamination problem, pulp from cottonseed oil production mainly used for cheap animal feed. . . . new process solves problem and one cottonseed mill already producing the more profitable flour.

Clean room technology: developed for Johnson by Pillsbury Co. (Minnesota) . . . . Pillsbury originally installed clean rooms, conducted employee training programs, and compiled a contamination control management practices manual for astronaut food production facility. . . . technology applied in all new food processing facilities at Pillsbury, clean rooms are installed in some older facilities, and all employees receive contamination hazards training . . . . improved product quality and reduced product recalls due to contamination. . . . managment manual (720 pages) is publicly available and used by FDA (District of Columbia) to train federal food inspectors.

Electronic strain gage: invented by founder of BLH Electronics. . . . improved and standardized by BLH for space program which was the first major market . . . . used by field centers (Goddard, Lewis and Marshall) and contractors in most rocket engine R&D projects and space vehicles such as the surveyor lunar lander. . . . commercial markets developed by BLH for standardized products. . . . product used by Armour and Co. (Illinois) in Armour Tenderometer since 1969. . . . unique capability to test hanging carcass and accurately predict meat tenderness after cooking, not possible previously. . . . Armour selects and guarantees all TesTender beef with instrument. . . . amount of premium-priced TesTender beef sold annually is tens of millions of pounds . . . . Armour was awarded 1973 Food Technology Industrial Achievement Award for Tenderometer, a major innovation in beef merchandising. . . . cattle growers using the instrument data for selective breeding programs.

Compressed/freeze-dried food: developed for Johnson. . . . marketed by Innovative Foods (California) as compact emergency food rations. . . . used by hunters, backpackers, etc. . . . sales expected to reach approximately $1 million within a year.

Weather satellite imagery and ground receiver: developed for Goddard. . . . used by National Weather Service (Maryland) as a major input to preparing daily fishery advisory charts for eastern Pacific. . . . charts transmitted by National Marine Fisheries Service (California) to radio facsimile receivers on 70 U.S. tuna boats in Pacific; represents 50% of U.S. tropical tuna fleet . . . . information reduces time and fuel costs for locating tuna, helps in avoiding adverse weather. . . . annual Pacific tuna catch worth over $75 million; provides 90% of tuna canned in U.S. (20% of U.S. fish consumption is canned tuna).

Aircraft remote sensing program and imagery: program by Johnson. . . . infrared photographic imagery of Midwest used in 1971 by Purdue University (Indiana) and U.S. Department of Agricultrue to analyze spread of corn blight. . . . Indiana portion of imagery used by Earth Satellite Corp. (District of Columbia) to map and measure coal mine refuse piles. . . . maps now used by Indiana legislature in preparing legislation on reclamation of mine refuse sites. . . . 200 sites larger than 2 acres each were identified and reclamation cost estimate exceeded $14 million.

Remote sensor for air pollutants: operational prototype developed for Johnson. . . . correlation spectrometer sold by Barringer Research, Ltd. (Canada). . . . over 40 sold @ $23,000. . . . unique air pollutant measuring capability. . . . measured NO_2 profiles over Los Angeles and San Francisco, SO_2 profile over Chicago. . . . also used by air pollution agencies in U.S., Canada, Australia, Japan, France, Spain.

Computer models for Apollo Program: developed for Johnson. . . . used by TRW Systems (California) to develop more than 30 air and water quality models . . . . provided technical basis for implementing pollution laws in Alaska, California, D.C., Ohio, South Carolina, Vermont.

Lunar Module rocket engine test facility: developed for Johnson. . . . used by TRW Systems (California) to develop inexpensive coal desulfurization process. . . . EPA funding at $1.5 million for research and pilot plant design . . . . process could eliminate need for expensive stack gas removal equipment for electric utilities. . . . SO_2 pollution control a critical financial problem for coal-fired power plants.

Computerized image enhancement: developed by Jet Propulsion Laboratory (California) to process digitized image transmissions from unmanned spacecraft (e.g., Ranger and Mariner). . . . used by JPL in current program to develop computer processing of water quality data from ERTS-1 multispectral digitized imagery. . . . joint funding by TUO and EPA (Oregon) to obtain cheaper, more efficient method for classifying quality of inland lakes in National Eutrophication Survey (NES). . . . good correlation between JPL results and EPA's water sampling data. . . . EPA initiated NES in 1972 to determine lake deterioration caused by phosphorus materials in sewage plant effluent.

FOOD PRODUCTION AND PROCESSING

Fracture toughness tests: developed by Lewis. . . . used at Deere and Co. (Illinois) to improve safety and service life of products (snowmobiles, farm tractors and implements). . . . reduced fracture failure of snowmobile drive trains, tractor roll-over protection systems (ROPS). . . . ROPS required by OSHA, Deere selected steel on basis of fracture tests. . . . 20% of research department effort on these applications. . . . Deere introduced new 150 hp. tractor in 1972, increased productivity 10% by pulling large implements or same implements faster. . . . implement service life not decreased, partly due to improved fracture toughness matching higher performance (e.g., plow striking rock could have caused brittle fracture). . . . Deere annual sales over $1 billion, about 25% of farm machinery market.

PETROLEUM AND GAS

Reliability and quality assurance methods: developed by Marshall. . . . used by Marshall, under contract to U.S. Geological Survey (District of Columbia and Louisiana), for 1971 study of functional reliability for safety and anti-pollution equipment on offshore oil/gas production and drilling platforms . . . . basis for improved assurance by federal government and industry that offshore oil and gas will be produced safely and with minimal pollution. . . . over 4,000 copies of report distributed to offshore industry worldwide by USGS . . . . USGS regulates all offshore operators on U.S. Outer Continental Shelf, including 1,800 drilling and production platforms in Gulf of Mexico. . . . new Recommended Practices issued by American Petroleum Institute (Texas) for subsurface safety valves and surface safety systems based on Marshall recommendations. . . . will be adopted by industry and included in USGS regulations . . . . will require licensing of equipment manufacturers in 1975. . . . additional API RP's based on Marshall study being prepared. . . . Offshore Operators Committee (Louisiana) designed computerized, industry-wide failure reporting system based on Marshall recommendation, and USGS is reviewing system before actual development and implementation. . . . Exxon Co. (Texas) and other offshore companies made equipment and operating changes to improve safety and reduce pollution hazards based on the study.

Cryogenic transfer system cooldown: data and analytic methods developed for Space Nuclear Propulsion Office and Lewis (NERVA Engine Program). . . . used by Chicago Bridge and Iron Co. (Illinois) to design piping systems at most large LNG import terminals in U.S. . . . cooldown rate of warm pipes at start of flow is a critical design parameter. . . . provided major input to CBI design of $7 million ship-to-shore LNG transfer system at Distrigas Corp. (Massachusetts) import terminal. . . . first (1971) major LNG import facility in U.S. (over 3 billion cu. ft. storage capacity). . . . also used by CBI to design ship-to-shore piping for Algonquin LNG, Inc. (Rhode Island, 6 billion cu. ft. storage in 1973), Columbia LNG Corp. and Consolidated System LNG Co. (Maryland, 5 billion cu. ft. storage in 1976). . . . U.S. annual LNG imports were 2 billion cu. ft. in 1971 and projected to be 2 trillion cu. ft. in 1980.

Insulation technology for Saturn rocket: developed for Marshall by Rockwell International Corp. (California). . . . RI licensed polyurethane insulation technology to Wanner-Isofi Co. (France) for worldwide LNG storage installations and NHK Spring Co. (Japan) for LNG tankers. . . . NHK is major corporation diversifying into shipbuilding. . . . RI conducts tests and provides consulting for licensees. . . . U.S. Coast Guard completing tests for RI prototype WET WALL Insulation System design for LNG tankers. . . . major development program for advanced marine insulation system. . . . expected advantages are signficantly lower capital and operating costs, increased volumetric efficiency and improved maintainability. . . . probable license or joint venture with U.S. shipbuilder after Coast Guard approval which is required for designs used in hazardous cargo tankers.

Apollo Guidance Computer software and Data communication methods: developed for Johnson by TRW Systems (Texas). . . . used by TRW Controls (Texas) to develop software and interface equipment for computerized control systems for oil field production, oil and gas pipelines. . . . major international supplier of such systems, over 3 dozen major oil and gas company customers. . . . provides "real-time" monitoring and control from central station. . . . high-speed

data transmission over voice grade circuits between central station and remote terminals is innovation in supervisory control systems. . . . computer systems replacing intermediate-level automation. . . . field production benefits through reduced operating cost and increased production. . . . Exxon Co. (Texas) has computer production control (mostly TRW) in 20 major U.S. fields (200,000 barrels oil and 850 million cu. ft. gas, daily) and estimates 1-2% production benefit . . . . other customers include Continental Oil Co. (Louisiana and California), Getty Oil Co. (Texas), Imperial Oil, Ltd. (Canada), Mobil Oil Corp. (Oklahoma, California, Louisiana, Pennsylvania), National Iranian Oil Co. (Iran), Shell Oil Co. (Louisiana, Venezuela), and MAPCO, Inc. (Oklahoma).

Multiplexer circuit for Saturn rocket instrumentation: developed for Marshall by SCI Systems, Inc. (Texas). . . . used by SCI in remote data acquisition and control systems product line. . . . systems installed on oil and gas pipelines and oil field production equipment. . . . provides better centralized monitoring and control, with less manpower. . . . 50 installations worldwide, 30 in U.S.

Heat pipe applications: developed for Marshall, Langley, and Ames by McDonnell Douglas Corp. (Washington) for Skylab, shuttle and unmanned satellites. . . . commercial heat pipe products developed by MDC include Cryo-Anchor soil stabilizers to prevent thawing of permafrost under structures in far north. . . . eliminates serious foundation stability problem. . . . MDC received $13 million contract from Alyeska Pipeline Service Co. (Alaska) to supply over 100,000 Cryo-Anchors for $5 billion Alaskan pipeline. . . . will be installed around pipe supports for 390-mile elevated portion of 800-mile pipeline. . . . Cryo-Anchors are 2" or 3" in diameter and range in length from 30 to 60 ft.

Infrared scanner and television display: operational unit developed for Marshall. . . . commercial infrared TV scanner developed. . . . product used for maintenance inspections at petrochemical plants and refineries by Allied Chemical Corp. and American Oil Co. (Texas). . . . Amoco remotely detects weak links, leaks, and off-specification equipment temperatures to determine maintenance problems. . . . improved plant efficiency and reduced pollution. . . . widespread interest in scanner by oil refineries caused by Amoco success.

Hot tapping method for pipes: developed for Johnson. . . . included in maintenance manuals used at all American Oil Co. (Indiana) refineries. . . . Amoco fabricated related equipment. . . . previously, pipe or valve leaks required up to 8 people and either partial shutdown or elaborate safety procedures . . . . new method done by one or two people in half the time, with no shutdown and little fire hazard. . . . refinery may have about six serious leaks annually.

CONSTRUCTION

Instrumentation electronics for Saturn rocket: developed for Marshall by SCI Systems, Inc. (Alabama). . . . design techniques and production methods used by SCI to design a ground fault interrupter that will fit inside a standard home circuit breaker. . . . interrupter prevents electrical accidents in home by tripping circuit breaker when ground fault current occurs. . . . required for all new homes in U.S. by 1971 Electric Code amendment. . . . normal annual rate of two million housing starts. . . . SCI sold 40,000 interrupter units/month before recent housing slump, market expected to improve.

Geodesic structure design program: developed for Headquarters by R. Buckminster Fuller at Southern Illinois University. . . . computer program used by Dome East Corp. (New York) to design commercial geodesic structures. . . . applications include recreational enclosures, greenhouses, homes and medical clinics. . . . 1973 sales $320,000. . . . $500,000-$1 million sales anticipated for 1974. . . . first domes made with plastic and vinyl coverings, but Dome East now experimenting with solid, laminated panels.

Reinforced plastic structures: initial work under DOD contracts. . . . development continued for Headquarters, Langley, and Lewis for high performance rocket motor cases, stabilizers, and liquid hydrogen pressure containers. . . . new plastic materials commercially used by Materials Systems Corp. (California) to fabricate wall panels for prefabricated housing. . . . plastic made from petroleum refinery wastes. . . . company, which was formed by aerospace engineers in 1970, holds contract with HUD-Operation Breakthrough Program. . . . currently building 1,100 units in California, 200 in St. Louis, @ $5,000. . . . over 10% cost savings compared to conventional factory-built housing. . . . additional installations in Mexico, France and Iran.

Fiberglass fabric: invented by Owens-Corning Fiberglas Corp. (Rhode Island) . . . . company developed first application for fiberglass fabric with 1967 contract from Johnson for nonflammable clothing and structures; included development of Teflon coating for fabric. . . . coated fabric used commercially in air structures developed by Birdair Structures, Geiger-Berger & Assoc. (New York) and others. . . . installations include a vinyl-coated fiberglass fabric covering for the U.S. Pavilion at Expo 70 in Osaka, Japan and the more commonly used Teflon-coated fabric coverings for stadiums and arenas. . . . $10 million/year industry.

TRANSPORTATION

Highway grooving: extensive research and testing at Langley (concept originated in England) to reduce airplane skidding on wet runways. . . . pavement grooves facilitate water runoff, improve contact between tire and surface, and reduce hydroplaning. . . . Langley results were basis for new highway/airport grooving industry with about $2 million annual business. . . . firms include Pavement Specialists, Inc. (Texas), Cardinal Engineering (Pennsylvania), Transportation Safety Systems, Inc. (Ohio), Super Cut, Inc. (Illinois), Charles R. Watts Co. (Washington), and C. W. Hatcher, Inc. (California). . . . over 25 states have contracted to have dangerous highway sections grooved . . . . wet highway accidents on grooved sections reduced by about 60%. . . . about 20% of accidents occur on wet pavement. . . . California Department of Transportation is leading user, with $8 million total outlay; applications include 400 miles of freeway grooved in Los Angeles area. . . . General Electric Co. (Ohio) produces artificial diamonds used in manufacture of groover cutting blades. . . . GE actively promoting grooving.

Apollo Guidance Computer software: developed for Johnson by TRW Systems (Texas). . . . used by TRW Systems (California) to develop first, real-time computerized traffic control system in U.S., SAFER (Systematic Aid to Flow on Existing Roadways). . . . prototype TRW SAFER installed and operating in 9-mile square South Bay area of Los Angeles County (California). . . . project cost about $800,000; funded by U.S. Department of Transportation Urban Systems Program (71%), County of Los Angeles (22%) and State of California (7%). . . . more than 15% reduction in millions of vehicle hours spent waiting

at 112 South Bay traffic lights. . . . estimated total annual savings to motorists using South Bay streets is $1 million. . . . projected total annual savings if SAFER were installed county-wide would be $50 million. . . . TRW also installing SAFER in Baltimore, Maryland (1,000 traffic lights) and Overland Park, Kansas.

NASTRAN (NASA Structural Analysis Program): developed by Goddard for computer analysis of aircraft and space vehicles. . . . continuing program maintenance services provided by Langley. . . . used by Ford Motor Co. (Michigan) for design analysis of car, truck, and farm tractor components since 1971. . . . more than 40 design engineers trained to use program. . . . influenced design of every major component in these products. . . . saved two-thirds of calculating time in achieving 60% improvement for component behavior predictions . . . . reduced R&D time and cost, as well as development testing costs (no valid cost savings figure available at this time). . . . General Motors Corp. (Michigan) recently completed development of design application methods to facilitate NASTRAN use by design engineers. . . . program calibrated with data from older vehicles. . . . corporate effort aimed at widespread use of NASTRAN in product design. . . . NASTRAN versatility and continued program maintenance service from Langley are very important to Ford and GM.

Rubber tire with low temperature pliability: developed for Johnson Apollo 14 Mobile Equipment Transporter by Goodyear Tire and Rubber Co. (Ohio). . . . used by Goodyear to develop new, studless winter automobile tire. . . . market testing started in 1974 with 4 cities: received good response. . . . price range from $71.25 to $79.45, with 4 sizes available. . . . provides traction equal to or better than studded tires on slick surfaces; also good traction on dry surfaces. . . . . several states are banning studded tires due to poor traction on dry surfaces and destruction of road surface.

Ultrasonic nondestructive testing techniques: developed for Marshall and Johnson by Automation Industries, Inc. (Connecticut). . . . company had over $2 million in contracts to produce innovative equipment for Apollo Program in past few years and has "had commercial spin-offs of several times that amount". . . . for example, Marshall funded the development of company's laboratory prototype into operational ultrasonic Delta Manipulator which Automation then marketed. . . . uses multiple transducers for significant improvement in testing rate and accuracy. . . . delta technique and ultrasonic test equipment now used by Automation in unique rail inspection service. . . . company has operated self-propelled railroad cars since 1928 to detect rail flaws with electric induction technique. . . . currently, 28 cars in operation on U.S. rails, 1 in Mexico, 2 in Australia, and others in Europe. . . . all cars now include ultrasonic test equipment, many use delta technique, and new cars use ultrasonics entirely. . . . one of the all ultrasonic cars used exclusively on New York City Transit Authority subway rails. . . . ultrasonics used to detect rail-end flaws (e.g., bolt hole cracks) and to complement induction method along rail. . . . over 500 million rail joints tested ultrasonically. . . . company does majority of NDT for U.S. rails; only one other NDT car exists, developed by a railroad. . . . since 1928 over 6 million miles of track tested; over 3 million flaws detected and track replaced. . . . over 160,000 miles of track now tested annually for 100 different railroads. . . . average testing speed for test cars is about 7 mph.

Apollo Guidance Computer software and Data communication methods: developed for Johnson by TRW Systems (Texas). . . . used by TRW Controls (Texas) to develop software and telemetry interface equipment in prototype computerized dispatching system for railroads. . . . prototype installed and being tested in part of Southern Pacific Co. (California) railroad system. . . . one of

most sophisticated train control systems in world. . . . TV displays provide central dispatcher with continually updated status of rail switches and trains; system provides for control of rail switches and train movement via light pen input on TV display. . . . test results favorable to date. . . . if prototype successful, Southern Pacific and TRW will develop computerized dispatching system for company's entire railroad system. . . . Southern Pacific is one of 3 largest railroads in nation; 4,000 miles of track, $1 billion annual freight billings.

Dynamic and static modeling techniques: developed by Marshall. . . . used by Martin Marietta Corp. (Colorado) in current development of dynamic model for railroad hopper cars. . . . TUO applications engineering project funded by Federal Railroad Administration and under technical direction of Marshall. . . . part of a major test program being conducted by Association of American Railroads to reduce number of derailments which are frequently caused by erratic behavior of hopper cars. . . . hopper car testing and model development underway at Martin to identify design modifications that will reduce erratic behavior.

HEALTH

Composite materials: developed by Langley for spacecraft, aircraft, and rocket motor applications. . . . used in two BATeams projects to design lightweight leg braces. . . . heavy, metal brace components replaced by molded composites. . . . prototypes tested at Coastal Center for Mental Retardation (South Carolina) and Mississippi Methodist Rehabilitation Center (Mississippi). . . . brace weight reduced by over 50%. . . . new braces improve mobility and are more attractive. . . . easier composite processing methods and cost reductions being developed to facilitate widespread availability of improved braces.

Polyurethane-silicone plastic foam: developed for Ames Integral Passenger Aircraft Seat Program. . . . contractor employee formed Dynamic Systems, Inc. (North Carolina) to market the material under trade name, TEMPER FOAM . . . . BATeam identified initial medical application, bed pads for long-term patients. . . . caused sharp reduction in bed sores. . . . each bed sore increases hospitalization costs by over $5,000; medical insurance typically allows 25% of expected expense for spinal injury cases to be for bed sores. . . . BATeams assisted in developing other applications which now include wheelchair cushions, artificial limb socket lining, and finger splint padding for patients with hand burns. . . . treatment of burns thus improved.

Mobile Automated Metabolic Analyzer (MAMA): developed at Marshall as TUO project using Skylab astronaut monitoring instruments. . . . now used in experimental program to measure energy expended by orthotic-equipped patients at Spain Rehabilitation Center, University of Alabama School of Medicine, an HEW Social and Rehabilitation Services research and training facility. . . . patient walks beside instrument cart rather than on the standard treadmill which disabled patients cannot easily use. . . . provides real-time data, under realistic conditions, for respiratory gases, EKG and velocity. . . . previous monitors measured only cumulative data for gases. . . . new data valuable in evaluation of treatment procedures and patient-assist device designs. . . . also includes Lunar Rover technology in design of battery-powered cart.

Nickel-cadmium battery technology: developed for Goddard by Johns Hopkins University (Maryland) for rechargeable spacecraft batteries (e.g., Small Astronomy Satellite). . . . used by Johns Hopkins to develop its patented rechargeable cardiac pacemaker. . . . six-year research effort funded by the University's School of Medicine, Baltimore City Hospital (Maryland), and Heart Association of Maryland. . . . Pacesetter Systems, Inc. (California) licensed by university to produce units. . . . first human implant for the product was in 1973; 1,200 implanted to date. . . . unit, with briefcase-sized recharger, costs $1,800. . . . provides rhythmic electrical stimuli to contract heart muscles and rehabilitate patients with intermittant complete heart block, one of major causes of fatal heart attacks. . . . rechargeable feature allows 10-20 years of reliable use, compared to 2-5 years for other units, before replacement surgery is required at a cost of over $1,500 per replacement. . . . weekly recharging takes 90 minutes . . . . patient anxiety about pacemakers reduced because recharger indicates whether unit is working properly. . . . current TUO-funded project at Goddard and Johns Hopkins to incorporate hybrid circuits in unit will further reduce unit's size and improve other features. . . . small size is required for children; improved cosmetic feature for adults. . . . new model will be implanted in 1975. . . . first total implant was in 1960; as of 1972, 120,000 pacemakers had been implanted in American patients.

Thick-film hybrid circuits and Mercury/zinc battery technology: developed for Goddard and Johnson by General Electric Co. (New York and Pennsylvania) . . . . used by GE to develop heart pacemaker product line. . . . over 4,000 units implanted since 1972. . . . current models provide 4-6 years of reliable electrical stimulation to rehabilitate people with certain types of coronary heart disease. . . . unit size reduced by 25% because hybrid circuits improve electrical efficiency by 45% and reduce interconnections by 50%. . . . recently improved batteries have 50% greater capacity than conventional mercury/zinc batteries.

Emergency care system for ambulance use: developed for Johnson as part of STARPAHC, a cooperative program with HEW to provide health care in remote areas. . . . SCI Systems, Inc. (Texas) partially funded by Johnson to develop portable emergency treatment module, Telecare, to meet STARPAHC remote use requirement. . . . Telecare incorporates Skylab telemetry and medical equipment designs. . . . SCI produced commercial units for ambulance use: allow trained ambulance personnel to communicate with physician, transmit EKG data and provide emergency resuscitation. . . . unit used in several Texas cities, including Houston, San Antonio and Corpus Christi; also Montgomery County, Maryland and Altoona, Pennsylvania. . . . federal funding allocated to local government for emergency medical training. . . . SCI product line recently sold to Telecare, Inc. (Texas). . . . two models now available, Telecare I and Telecare II; unit price range $3,700 to $9,000, depending upon configuration. . . . Telecare, Inc. currently establishing international sales force.

Fluorometer instrumentation technology: developed for Headquarters, Marshall, and Electronics Research Center for diagnostic and Apollo instrumentation by Whittaker Corp. (Massachusetts). . . . used by Whittaker to develop new blood and urine lead detection device, Micro-Porph. . . . 10 to 15 instruments sold, current unit price approximately $3,000. . . . used by public health agencies, such as New York University Medical Center, Baltimore City Hospital, and St. Louis City Health Department, for mass screening of incipient lead poisoning. . . . permits low cost screening by unskilled personnel: 2-minute test costs approximately $1.00 compared

to longer conventional lab test @ $5.00 to $8.00. . . . applications include people who live in areas with high lead pollution levels in the air and children who ingest lead-base paint. . . . estimated 400,000 children in U.S. affected by lead poisoning, with 200 deaths reported annually . . . . early detection can avoid permanent damage and death. . . . extent of lead poisoning a major factor in restrictions on lead-based paint and shift to unleaded gasoline.

Portable laminar airflow surgical clean room: developed for Headquarters by Martin Marietta Corp. (Colorado) for experiment in control of surgically induced infections. . . . installed for evaluation of St. Lukes Hospital (Colorado). . . . included state-of-the-art aerospace clean room technology, helmet and gown isolator system, and communication system . . . . used during 550 orthopedic surgical cases over 2-year period. . . . JPL evaluation of system effectiveness indicated personnel isolator system reduced contamination levels below those achieved with only laminar flow room and much lower than conventional surgical room. . . . major need exists to reduce postoperative infection associated with prosthetic implantation.

Heat pipe applications: developed for Lewis and Langley by Hughes Aircraft Co. (California). . . . used, together with aluminized mylar superinsulation, by Hughes to develop portable cryosurgical instrument product, Lewis Kryostik . . . . approximately 800 units sold since 1972 @ $1,000. . . . 2-lb. self-contained instrument supplies liquid nitrogen to cryoprobe tip for controlled destruction of tissue. . . . surgical applications include proctological procedures such as hemorrhoidectomies, destruction of malignant tumors and treatment of cervicitis. . . . allows 65% reduction of application time compared to other cryosurgical instruments. . . . compared to conventional surgical methods, advantages in Kryostik hemorrhoid removal are: no hospitalization, no anesthetic, less pain, faster recovery and lower cost. . . . experiments on lab animals indicate Kryostik stimulates auto-immunity to cancerous cells: positive results in 75% of cases studies.

SPACELAB

Mr. BOLAND. We will turn to volume I, research and development, page RD 2–1, Space Flight Operations. We see that the fiscal year 1977 budget requests an increase of $16,600,000 above the current estimate for fiscal year 1976. A substantial part of that is reflected on pages RD 2–4 and 2–5, in connection with the Spacelab.

The Europeans, of course, are paying the development costs of the Spacelab. What will be the total United States commitment to the Spacelab?

Dr. FLETCHER. We have the approximate number. Mr. Yardley, do you have that estimate?

Mr. YARDLEY. I will have to do a little adding.

Dr. FLETCHER. We contribute nothing to the Spacelab itself. But we do contribute peripheral equipment.

Mr. YARDLEY. The total fiscal year 1977 budget runout dollar figure for all of our activities, including what we are planning to buy from the Europeans, is approximately $129 million. This purchase will fulfill our international commitments and provide a capability for up to 12 flights per year.

Mr. BOLAND. Say that again.

Mr. YARDLEY. The total Spacelab cost that the United States will bear in terms of our development and flight hardware, and so on, is $129.5 million.

Mr. BOLAND. That would be our total contribution. Is that correct?

Mr. YARDLEY. Yes. That is for the total runout.

Mr. LILLY. Mr. Chairman, we have certain development responsibilities in this, such as the crew transfer tunnel and items of this nature. They total about $21 million. The number he has given you includes the flight hardware procurement that we are committed to buy after they have delivered us a unit, and our estimate of the software, training, and other items that will be required in the operation.

SPACELAB SCHEDULE

Mr. BOLAND. The February 2 issue of Aviation Week describes some problems involving the Spacelab. It notes that schedule slippages have resulted from design changes and requirements, particularly those imposed by the Shuttle development. What is that all about? Is the Spacelab currently behind schedule?

Dr. FLETCHER. Mr. Yardley can answer that. I did have occasion to visit the ESA group last summer, and they were just barely getting started, Mr. Chairman. The Spacelab is not going to be flown until 1980. I think any slippages or apparent slippages are early milestones having to do with documentation, interchange specification, and things of that type. John Yardley has been visiting them more recently. John, would you comment on this?

Mr. YARDLEY. Of course, ESA has made a complete reevaluation of their schedule in the last several months, and they have testified before our Authorization Committees. Their end dates for delivery of the items to us are still satisfactory to meet our present schedule.

We have some concern in their getting started. Their near term milestones have slipped some, and we are working with them to see

if the rest of the schedule will be satisfactory, or if there may be substantial slippage.

Now, with regard to the Aviation Week article and the Shuttle/Spacelab interface, I think this is primarily just the normal course of doing business. They are two very sophisticated vehicles, and we have to work out how the data systems, the environmental systems, and other items are going to work together. We had a meeting last month with a number of ESA people, and ERNO people came over and visited Rockwell with NASA representatives. We have about 80 percent of the technical information settled on the interfacing. So I think that that is in good shape now.

Mr. BOLAND. Would it make any difference if you fell behind from 3 to 6 months, anyhow?

Mr. YARDLEY. It would impact our planned early flights. The first flight we have after our first six development flights is a spacelab flight, a joint flight with the Europeans. And then, there is another one very shortly after that. So it would affect our flight rate in the early months.

ADVANCED SYSTEMS

Mr. BOLAND. Turning to page RD 2–19, Advanced Systems. In fiscal year 1976, the estimate is $12 million, and the 1977 request is $13 million. It is interesting to note that the text describes an early space station concept, carrying from four to six people, that would utilize the Skylab, Shuttle, and Spacelab technology with minimum hardware modifications. Is this the next major thrust in NASA's thinking?

Dr. FLETCHER. Mr. Chairman, we have been spending a great deal of time thinking about that. As a matter of fact, just today, I believe, we sent you a copy of a report that we just completed. It is a year's study called Outlook for Space.

Now, this is not a program for NASA. This is a study by a task force that we set up, which looked at the potential of the 1980's. The space station—especially a less expensive one, as described here—was high on their list of priorities to pursue. But we have not made the decision as to whether or not that is the number one priority. It is certainly a likely possibility.

Mr. BOLAND. Is something like a space station required if you are going to assemble a solar power station in space? You talk about a solar power station in the legend here.

Dr. FLETCHER. That approach seems to be, so far, the best way to establish a solar power station in space. I cannot say that using a space station is the only way to go, but that is the way that looks the most promising at the moment.

SPACE STATION COST ESTIMATES

Mr. BOLAND. Have you projected what the cost might be for this kind of a project?

Dr. FLETCHER. For the first space station, the Outlook for Space group did make an estimate. As I recall, it was less than $2 billion for this six-man space station. I do not know how reliable those numbers are. They are put together by a task force. But I would guess that is a good rough estimate.

Mr. YARDLEY. There is currently a competition for dual studies on this space station concept, so we will have much better estimates about a year from now.

EXPENDABLE LAUNCH VEHICLES

Mr. BOLAND. On page RD 3–1, under Expendable Launch Vehicles, you are requesting $151,400,000 in fiscal year 1977, as compared to the $165,900,000 fiscal year 1976 plan. Only one question: are any of these funds for long-lead procurement of boosters beyond calendar year 1980?

Mr. YARDLEY. No, sir.

SPACE SCIENCE PROGRAMS

Mr. BOLAND. Turning to the space science programs, page SS–1, we can see from this table that the fiscal year 1977 budget request of $379,025,000 is about $55 million less than the current fiscal year 1976 level. All that reduction is in the lunar and planetary exploration areas. Is that correct?

Dr. FLETCHER. Nearly all the reduction is in the lunar and planetary area.

SOLAR MAXIMUM MISSION

Mr. BOLAND. Under the physics and astronomy program, on page RD 4–9, the solar maximum mission is described. This is a new start in fiscal year 1977, and you mention it in your statement. You are requesting $21,300,000 to initiate it. How many solar maximum spacecraft will there be?

Dr. HINNERS. There will be one spacecraft, sir, retrievable by the Shuttle so that we can use it again in the 1980's.

Mr. BOLAND. I notice that this mission is scheduled for launch in 1979. I also notice that on a list of preliminary payload candidates for the six development flights of the Shuttle in 1979, the solar maximum mission had been listed as a possible candidate for the fourth flight. However, this list has that mission crossed out. Why is this? This would then seem like a natural candidate for the Shuttle.

Dr. HINNERS. We are now programing this for a Delta launch. The scheduled solar maximum mission (SMM) launch is in the last quarter of 1979. It is essential to catch the solar maximum period. We have to guarantee that we can get the SMM launched on that time schedule, so we are making it compatible with a Delta launch.

Mr. MCDADE. Would you yield, Mr. Chairman?

Mr. BOLAND. Yes.

SIGNIFICANCE OF SOLAR MAXIMUM MISSION

Mr. MCDADE. Dr. Low, what is the mission going to accomplish? What do you hope to be able to tell us as a result of the solar maximum mission?

Dr. LOW. I would like Dr. Hinners to answer the question.

Dr. HINNERS. In the solar maximum mission, we are looking basically at the flare process. A flare puts forth a very large amount of energy in a few minutes. We do not yet understand how the energy is concentrated and then triggered and released, and how it propagates out ultimately to affect the Earth's atmosphere, ionosphere, and par-

ticle environment. By understanding this solar flare mechanism, we are hoping to make basic advances in physics; essentially, to understand this tremendous energy concentration and release. The solar maximum mission will do this by focusing seven experiments with fine pointing on a flare area.

Previously, we have not been able to study a flare from the X-ray, the gamma ray, and the visible region at the same time. We have put a patchwork story together on what solar flares are and what they do. But this mission will be our first opportunity to do an integrated study of the flare generation mechanism, to understand the basic physics of solar energy generation and its effect, ultimately, on the Earth.

We are flying the solar maximum mission at the same time as some satellites in our Explorer program, which includes the International Sun-Earth Explorer series. While the solar maximum mission looks at the flares, the International Sun-Earth Explorer will be looking at the Earth's atmosphere and magnetosphere, so we will start to see the coupling which Dr. Low referred to before. We will see the correlation of solar flare activity with the Earth's weather patterns.

Dr. FLETCHER. I do not like to delay you very much longer, but this is a very interesting phenomenon. If you ever get a chance to see the movies that we took of solar flares, the energy usually comes out in a big ring and returns back into the Sun. You will see a big circle following the lines of force of the magnetic field of the Sun. But every now and then, one just pops instead of coming back. The circle opens, and a whole stream of particles comes rushing out, and a fraction of these hits the Earth every time that happens. And it is when those solar flares burst through the magnetic field somehow that you get these big disturbances in your radio reception. It does look as though that has some effect on the stratosphere now, and who knows? It may affect climate. I hope we are wrong on that, but it is a very interesting phenomenon.

Dr. Low. The specific answer to your question, Mr. McDade, is that we are trying to understand the detail of the mechanism between what happens on the Sun and how the Earth's climate is affected. Once we can understand this, then, of course, the next step will be to do something about it. But first, you have to understand it.

SOLAR MAXIMUM MISSION COST ESTIMATE

Mr. BOLAND. What is the total cost of SMM?

Dr. HINNERS. The planning estimate is a range of $75 million to $90 million for the runout cost, excluding the Delta launch vehicle cost of approximately $6 million.

Mr. BOLAND. Would you provide for the committee an estimate of what would be saved if the solar maximum mission were flown on a Shuttle rather than by conventional booster?

Dr. HINNERS. Yes, Mr. Chairman.

[The information follows:]

The solar maximum mission (SMM) is scheduled to be launched in the forth quarter of 1979. This schedule is based on maximizing the scientific returns, since the mission is planned to take advantage of the opportunity to study the sun during the next period of peak solar activity.

The Space Shuttle is not scheduled to begin initial operations until mid-1980. The first operational flight is scheduled to be a Spacelab mission. The orbital flight tests (OFT) planned for the preoperational phase, to begin in 1979, will not be conducted at the 550-km altitude required by the SMM. To translate the SMM from the planned lower orbit of the Shuttle OFT to 550 km would require the development of a deployment mechanism and the development of a propulsion module.

The SMM is presently designed to be retrieved by the Shuttle system for refurbishment and possible reflight on Space Shuttles later in the program. The cost of developing another SMM spacecraft and some experiments would be saved in that event. Although the conventional booster costs are known, NASA is currently studying the tariff for payloads.

SPACE TELESCOPE STATUS

Mr. BOLAND. On page RD 4–26, there is a little item here that is now very controversial. As the justification indicates there are no funds requested for the Space Telescope in fiscal 1977. It was cut by OMB during the budget preparation stage, and as all of us know, this subcommittee has had serious misgivings about the ST. But before we get into that, we would like to get caught up on the latest cost and other data estimates. And if Mr. Hinners would provide the committee with a short briefing on the ST—do you want to do that now?

Dr. HINNERS. Yes, Mr. Chairman, we can give you a status report on the Space Telescope. I think it might be helpful if I just passed these out to you, so you can follow along. I will bring you up to date on where we stand technically, on the status of some of the key development items.

As you know, we did focus this last year on the 2.4 meter aperture Space Telescope. We had been studying the 3-, the 2.4-, and the 1.8-meter telescopes and determined that the 2.4-meter system was the way to go. That was the smallest aperture that would still maintain a significant advance in the science objectives over previous space- and ground-based astronomy.

SPACE TELESCOPE CHARACTERISTICS

This chart lists the Space Telescope characteristics that we have settled on for the scientific characteristics. (Figure SA–1)

FIGURE SA–1

SPACE TELESCOPE CHARACTERISTICS

Primary mirror: 2.4-meter diameter.
Angular resolution: 0.1 Arc sec.
Primary f/number: 2.3.
System f/number: 24.
Spectral range: 1150A—1 mm.
Limiting magnitude: 27.
Number of scientific instruments: 4.
Stray light baffle: Fixed.
Total spacecraft weight: 7,730Kg (17,000 lbs).
Moment of inertia: 59,000 Kg-m^2.
Pointing and stabilization: Reaction wheels.
Electrical power: 1,500 watts.

Starting with the diameter on down through the number of instruments, the weight—all of these have made it completely compatible with the Space Shuttle. We have adequate margin in terms of weight,

so we feel that there is no problem in that area now. We can use the weight-carrying capability of the Shuttle to simplify the solution to technical problems that would require, say, adding weight.

ROLE OF SPACE TELESCOPE

The next chart summarizes the key role of the space telescope.

FIGURE SA-2

ROLE OF 2.4-METER SPACE TELESCOPE

The ST will be the first long-life optical space observatory; shuttle launched, serviced, and retrieved.
Unique capability in resolution and sensitivity:
- Opens up ~100 times volume of space.
- Resolve stars in other galaxies.
- Determine energy output of quasars.
- New technique to detect intergalactic matter.

The ST complements and extends ground-based and other space astronomy.

We have reworked those during the past year, both through our advisory groups and with other Federal agencies involved in astronomy. The Space Telescope, when launched, will be the first long-life optical space observatory. We are talking about a 15-year minimum lifetime which will include Shuttle refurbishment and replacement of experiments.

The scientific community does agree that the Space Telescope will open up over 100 times the volume of spaec to exploration over that which is currently available from ground-based and other space-based observatories. For the first time, we will be able to study individual stars in other galaxies. This morning, we talked about other galaxies, but we have not yet come to the point where we can make detailed observations of stars in those galaxies. The Space Telescope, will give us that ability.

An important role will be to determine the energy output of the strange objects called quasars. These are objects in space, at some unknown distance, which emit very large amounts of energy. We are not able to tell exactly where they are located until we can get a telescope into orbit which can let us calibrate the distance scale out to the farthest reaches of the universe, as the telescope will allow us to do. It will give us new techniques to detect intergalactic matter. We are not focusing just on the stars themselves. Possibly as much as 80 or 90 percent of the mass of the universe is present as intergalactic, interstellar matter, not as discrete objects. With the Space Telescope, we can get a good measurement now, we feel, of how much of that mass exists in intergalactic, interstellar space, and what its distribution is.

This addresses the question of: Is the universe going to expand forever, or is there enough mass that it will start to contract and come back in on itself?

Dr. FLETCHER. Do not worry about it. That is probably 20 billion years away.

Dr. HINNERS. I did not mean to cause any panic. We are convinced that the telescope does complement and extend the ground-based and other space-based astronomy.

SUPPORT SPACE TELESCOPE

On the next chart, you will see that the National Academy of Sciences continues to endorse the space telescope as a leading high-priority space project (Fig. SA–3).

FIGURE SA–3

SPACE TELESCOPE

National Academy of Sciences, Space Science Board (SSB):
Continues to support ST as high priority science.
Joint SSB-European Science Foundation meeting in January 1976.
"The capabilities of the LST therefore represent a natural and achievable progress in astronomical technique, of a magnitude and importance that exceed those of all other likely developments in optical astronomy over the next few decades."
ST plans are coordinated:
Interagency Coordinating Committee on Astronomy.
ST does not duplicate, but complements and enhances programs of other Federal agencies.

In January, the European astronomy community met with the Space Science Board and at the conclusion also gave a very powerful endorsement of the European astronomy community to this project.

We have worked with the National Science Foundation and other Government agencies through the Interagency Coordinating Committee on Astronomy to be sure that other agencies are completely aware of our plans and what we are claiming the telescope will accomplish. They are in agreement that the telescope does not duplicate but, indeed, complements and enhances their programs.

They are counting in large part on NASA and our telescope development for detectors that will be used for the ground-based observatories, as well as for the space telescopes.

CURRENT STATUS

In terms of our current status, the telescope and spacecraft study contracts do end in March of 1976 (Fig. SA–4).

FIGURE SA–4

SPACE TELESCOPE—CURRENT STATUS

Telescope and spacecraft study contracts completed—March 1976.
Major advanced technological development tasks completed.
Candidate focal plane instruments defined.
Currently reviewing procurement options.
Next step is full funding in fiscal year 1978.

There are now no further plans for funding those contracts.

The major advanced development tasks are completed. This includes looking at the stray light model, which gives us confidence that we can use the telescope in daytime, that stray light from the terrestrial atmosphere will not be a significant problem.

The thermal control has been pretty well ironed out with the graphite epoxy type structure. The fine guidance sensor for the pointing accuracy needed we feel is well developed. The instruments have been defined by the telescope working team. This is probably our area of great-

est concern. The detectors are the long leadtime items and represent an area where we feel that some work should be kept going, particularly this next year.

We are reviewing procurement options. We fully appreciate and understand that contractors who have been involved have large teams in existence and that the prospects of a year or longer delay in initiating or requesting initiation of this——

Mr. BOLAND. Who are the contractors that have been involved? Are there many?

Dr. HINNERS. There are five. Itek and Perkin-Elmer have been the prime study contractors on the telescope and instruments. Boeing, Martin and Lockheed have been the prime study contractors on the support systems module.

At the request of the authorization committees, we are looking now—and expect to have an answer in about a month and a half, in early April—at the implications of an early competition and contractor selection. We are looking at all the implications very carefully because it is not obvious that it is completely advantageous to the Government to make early determinations in competition before any funding or program is approved. You might be somewhat at the mercy of the person you have selected when it comes to negotiating new positions and changes in a program.

We now contemplate that the Office of Space Science will propose a fiscal year 1978 start of the Space Telescope, in which case it would be reviewed as part of the fiscal year 1978 budget process with OMB and the Congress.

STATUS OF KEY TECHNOLOGY

The last chart lists the status of key technology. I addressed some of that earlier. (Figure SA–5)

FIGURE SA–5

SPACE TELESCOPE—STATUS OF KEY TECHNOLOGY

1.8–meter lightweight mirror polished 25 percent more accurately than required for space telescope ($\lambda/65$).

Laboratory simulation has demonstrated achievability of required 0.01 arc sec pointing stability (0.005 arc sec has been attained on OAO for short periods of time).

Tests of a variety of metering structures demonstrated ability to maintain required close tolerances in space environment.

Analytical model, verified by laboratory measurements, demonstrated that stray light will not interfere with observations.

Laboratory version of 70MM (2¾-inch) sec orthicon operating with desired sensitivity and resolution.

I think maybe it would be best to turn to any specific questions you might have. My summary, I hope, brings you up to date on where we stand in our study and advanced technological development activity in support of the Space Telescope.

ESTIMATED COST OF SPACE TELESCOPE

Mr. BOLAND. Last year you told the committee that when phase B studies were nearing completion that you would be able to provide an estimate of what this project would cost. The studies are now nearing completion, and, of course, you had to give OMB an estimate last

September when you requested initial funding of the Space Telescope.

What is the current estimate of the cost of the Space Telescope?

Mr. LILLY. Slightly over $400 million.

Dr. FLETCHER. That is the estimate in the dollars of the fiscal year 1977 budget.

Mr. BOLAND. And what are the operational costs over the 15-year period, or the life of the project?

Dr. HINNERS. We are still refining that number. The present estimates are in the range of $10 to $15 million per year. The uncertainty comes from not knowing at this time how many experiments one would change at what point in time; how many refurbishments would be needed—that is a function of how successful it is; and how many visits would be required to the telescope.

Dr. FLETCHER. I think there is an additional uncertainty. That is, the Europeans have indicated their interest in contributing to that operational cost. We do not yet know how much that contribution would be.

Dr. HINNERS. This number is in line with what it costs to keep a good ground-based complex of observatories going.

INTERNATIONAL PARTICIPATION IN SPACE TELESCOPE

Mr. BOLAND. Two years ago this committee recommended in its report that you seek substantial additional international participation in the LST. Last year, on page 431 of the hearings, in response to a question by Mr. Shipley, you indicated that you expected outside participation by other countries to be in the 10- or 20-percent range, rather than a third to one half.

Is that still holding?

Dr. FLETCHER. I think so. We tried very hard, Mr. Shipley, to find a piece of the structure that could be built by the Europeans, but you cannot divide the mirror in pieces that the Europeans could build. It just did not work out.

The biggest contribution could be in the instruments you attach to the Telescope. I think that is more in the 10- to 20-percent range. We just could never get it up in any reasonable fashion to the 30 percent that you indicated.

GAO COMMENTS ON SPACE TELESCOPE

Mr. BOLAND. I noticed that in the GAO report, on page 2 of the ST report, it reads thusly:

> Although no formal commitments have been made, NASA estimates an $18 million reduction in cost for work to be provided by international participants.

Of course, that is nowhere near the 20 percent mentioned to Mr. Shipley.

Mr. SHIPLEY. Will the chairman yield?

Mr. BOLAND. Yes.

EUROPEAN PARTICIPATION

Mr. SHIPLEY. I notice, Dr. Hinners, in your more or less justification of the telescope, you cited on one of your pages that the the European science foundation meeting in January when they said it was a great

project and it should be carried on, et cetera—how much money are they contributing?

They think it is a great project, certainly, because they can use it. But how are they participating?

Dr. HINNERS. The European participation would be through ESA. They are envisioning, still, three areas: an instrument, possibly part of the power supply, and the ongoing continuing operations, part of this $10 to $15 million that I referred to.

Mr. SHIPLEY. But you have no idea what percentage of the operating cost they would carry, do you?

Dr. HINNERS. In our early discussion, we talked about them supplying the equivalent of one-third when we have the ongoing operations.

Now, this is in conjunction with what has been called sometimes the Astronomy Institute and the science operations, which would be on the order of $1 to $2 million per year continuing on their part. Their proportion of the observing time would be proportional to their contribution. In other words, they would not get half or a quarter of the observing time by putting in only 10 percent of the cost.

Mr. SHIPLEY. Yes. But they would benefit from everything that we found, would they not? Whether they used it or not, they would have benefits of that science?

Dr. HINNERS. Yes; that is true of all our projects. The science, indeed, is completely in the public domain.

Mr. SHIPLEY. So whether they actually were using the object does not matter that much, because they would still be the beneficiaries of anything we may learn. Right?

Dr. HINNERS. To the man in the street, yes; but to the scientist, no. The scientist wants to be there, doing it himself. The European astronomers do want to participate.

Mr. SHIPLEY. I am sure that they do. There is no doubt in my mind that they want to participate. They want to participate in the use of it, but they do not want to participate in the cost of it.

Dr. FLETCHER. Mr. Shipley, I think your point is well taken. But you have to deal with two different groups here.

There is the European Space Agency, which would be the group that contributed the dollars. And then there is the European Science Institute or foundation members, who would be the users.

Now, it is true, they have to work together. But let me address the point.

If they do not participate in the use of the telescope, their astronomy program will go downhill, because they simply will not have the scientific competence. Once they have dropped the use of an instrument such as this, all the impetus for new astronomy discoveries will be in this country, rather than in Europe. They know that very well, and that is why I think they are very anxious to contribute.

Mr. SHIPLEY. And all you are talking about now as far as outside contributions are concerned would be some equipment that would be on the telescope?

Dr. FLETCHER. That is all we could really draw a line on and say they could properly or competently do. It was our decision that they could not do any more than that, but that still can be in the range of 10 to 20 percent of the cost.

Mr. SHIPLEY. Are you saying they are going to manufacture the instruments and furnish them to you?

Dr. FLETCHER. Yes, sir.

Mr. SHIPLEY. How about dollars? Can they not contribute dollars?

Dr. FLETCHER. They will. The intent is that they would contribute dollars.

Mr. SHIPLEY. You are talking about what I would call "in kind." I am talking about actual cash layouts.

Dr. FLETCHER. There would be two parts: the operation, the year by year operational costs——

Mr. SHIPLEY. But you are talking about a very, very small part, Doctor.

Dr. FLETCHER. It might even be 20 to 30 percent of that $15 million per year.

Mr. SHIPLEY. Of the operating costs. But I am talking about over $400 million. What would their equipment contribution be equivalent to in dollars?

Dr. FLETCHER. In terms of the equivalent dollars in equipment, I think we are still talking only about 10 or maybe 15 percent. That is correct; on the equipment itself.

Mr. SHIPLEY. I am not going to go into it any further, Mr. Chairman. I just do not believe that we have worked hard enough to make the other countries, who are going to benefit from the very knowledge that we gain, contribute. Yet, they will have that knowledge, they will get that knowledge.

Maybe their science will slow down. There is no question that it probably will. But I just think it is a shame that, continually, we have to carry the load throughout the world in all of the science exploration. I think that we have.

Dr. HINNERS. Mr. Shipley, might I add one comment?

Mr. SHIPLEY. Sure.

Dr. HINNERS. ESA has a relatively fixed budget that they put into science programs. On the telescope, in large parts, they do not have the capabilities of things I have just been talking about in advanced technology, such as the graphite structures, the mirrors, et cetera, which we have now demonstrated.

Mr. SHIPLEY. That has nothing to do with making a cash contribution.

Dr. HINNERS. Yes, sir, as far as that goes. But they have expressed a desire, which I can sympathize with, that when they do put money into a program, they also are trying to put it into an area which will benefit European technology.

Mr. SHIPLEY. There is no question in my mind that that statement is exact. Certainly.

Mr. TALCOTT. Are there other programs in international affairs that the Europeans contribute a higher percentage, such as the exploration in Antarctica? Are they willing to put more money in, a higher percentage, in research and development there?

Dr. FLETCHER. Yes, they do. But they still hold to this fundamental premise in every program that I know of, and that is, they do not transfer dollars. They transfer in kind, as Mr. Shipley points out.

They will put in, say, 30 percent of the program, but that means they have to manufacture that in their countries, so they gain the benefit of the technology.

I know of no program, Mr. Shipley, although maybe you do, where they actually spend dollars over here for instruments developed in this country.

Mr. SHIPLEY. Talking about hardware construction, it is always our dollars going this way.

Dr. FLETCHER. We do not allow our dollars to go the other way, either. We are very careful about that.

JAPANESE INTEREST

Mr. MCDADE. What about the Japanese, for example, on programs like this?

We are talking about Europe only. What about the Japanese?

Dr. FLETCHER. We have not engaged in as serious a discussion with the Japanese on this particular program. They are interested in the Space Shuttle.

Mr. MCDADE. Any reason why not on this program?

Dr. FLETCHER. I do not know. Go ahead, Noel.

Dr. HINNERS. The Japanese astronomy community is extremely small, relative to the European community. So their inherent interest is much less. Their space science area is strong in the magnetospheric physics, and there they have expressed interest in participating in one of the SHUTTLE payloads with us and contributing an instrument to that.

INTERNATIONAL PARTICIPATION

Mr. TALCOTT. I think that Mr. Shipley's point is well taken. But in airplane technology, I think we should spend our own money on that because we are trying to keep a competitive advantage and we want to sell overseas. We are not interested in giving away all our secrets.

But in mathematical developments and other basic scientific developments, research and development in the sea, I would think all of these other countries would be interested in contributing a higher percentage of the gross national product, because of the tremendous advantage they might gain.

Is there some way that we could encourage them to contribute more?

EUROPEAN DEVELOPMENT OF SPACELAB

Dr. FLETCHER. Mr. Talcott, you are absolutely right. In areas where they can contribute, they do, and we encourage it.

Spacelab is a good case in point. The Europeans are paying for the development of the Spacelab—$515 million. In the case of the Space Telescope, it would be basically ourselves. We just did not see that they had the capability to build any piece of that telescope, except for the instruments themselves. There was no way that we were going to take a chance on that complicated a project with a country or a company that did not have that capability.

On Spacelab, we said yes, you can. They were very anxious to help and are funding that development.

Mr. TALCOTT. Why could they not just contribute dollars? Just write out a check.

They could say, we do not have the technology, but we want to be involved.

Dr. FLETCHER. That is hard to get the Europeans to do. I do not know of any program they have ever done that on.

Mr. BOLAND. Was it done in the Helios program?

Dr. FLETCHER. No. They contributed in kind on Helios.

Mr. BOLAND. They contributed about half the cost, did they not?

Dr. FLETCHER. About two-thirds.

There is one exception. They do pay for launch cost of their satellites when they have a commercial launch or a defense launch and so forth. They do transfer dollars. I could not think of an exception, but that is the exception.

Mr. SHIPLEY. The point is, if they wanted to, they could do it, Doctor. And the point is, they are not going to do it, because they know full well that this country is going to go ahead and do it.

Mr. BOLAND. Maybe.

Mr. SHIPLEY. They are judging on past history.

I can only think of one project that was ever canceled, and that was the Mohole project several years ago.

Mr. TALCOTT. How about the deep core ocean drilling project, where the countries all contribute money?

Dr. FLETCHER. I am not familiar with that program.

Are you, Noel?

Dr. HINNERS. I was not aware that they put money out for that. I knew they put personnel and ships out.

Mr. TALCOTT. I think you can see that many Members of Congress are getting more conscious about the dollars and the responsibility of other nations to take part in some of these programs. We have taken a leadership for which we have gotten some advantages. But perhaps they ought to do more of that.

Dr. FLETCHER. In every case so far with us, they have contributed in kind. There is no transfer of dollars to pay for our equipment.

CAUTION ON TECHNOLOGY TRANSFER

Mr. MCDADE. Does that not raise a question? You know if we agree that any time we have got a shot going, and we permit them to get in on it, we are letting them advance.

Comment on that, if you will.

Dr. FLETCHER. Each case is different. But let me give you an example.

In the case of the Spacelab, we concluded that the Europeans did have the capability for developing the Spacelab, with the exception of a few items and peripheral equipment that we will provide.

Now, they have this capability. They wanted us to help them in exchange for that with another vehicle they are building called the Arianne, which is a launch vehicle. They knew about our expertise, and reliability, and quality control, and systems engineering. And we said, no, we do not get anything for that, so why should we contribute to your technology?

It is not an easy thing to do, but we are very careful about the transfer of that technology, because they are going to be our competitors, and we want to watch that.

Mr. MCDADE. I do not think we ought to stray from the point that was raised, either, about them putting up resources in terms of

dollars, rather than just technological efforts. We may look around and find competition developing to areas where our industry has been the cutting edge.

I realize that it is a difficult problem for you. But I am conscious of it, and I am sympathetic to the point that Mr. Shipley raises about attempting, through appropriate mechanisms, to get more help from foreign governments that are going to benefit. I do not necessarily mean in kind contributions at all; I want to emphasize that.

I know it is a hard problem. I know they look at their own set of national interests. I hope we do, too. That is the way it ought to work. But it does seem to me that they get a lot of free rides on a lot of things that we do.

Dr. FLETCHER. Not so much any more.

Mr. TALCOTT. But we as a nation, as a people, as business entrepreneurs, have been very generous with the rest of the world.

Dr. FLETCHER. That is correct.

Mr. TALCOTT. The oil drilling technology was ours 100 percent. We developed it, and the first oil well. We did everything, and we have practically given it away. And now we are at their mercy.

Dr. FLETCHER. I think that pendulum has shifted. It has certainly shifted in NASA, and we are very careful about this question of technology transfer.

Mr. TALCOTT. I am worried about the airplane development. At one time, we had almost 95 percent of all the airplane production and sales in the world, and I think we are losing it. The Concorde is just one example. That is partly Congress' fault, but there are other ways we give away our technology.

Dr. LOW. We are very much concerned about that, particularly in the aviation industry. We talked about that this morning.

Aeronautics is one of the few remaining areas that we do have a major lead, and we intend to help maintain U.S. leadership by providing sound technology.

Mr. MCDADE. Is there any mechanism outside of the European space community by which NASA attempts to talk to other free world nations about help in terms of dollars?

Dr. FLETCHER. Of course, you know about the mechanism that is in place for exchanging information with the Soviet Union. We have a number of bilateral committees.

Mr. MCDADE. I was addressing myself to free world countries.

Dr. FLETCHER. We do not have any such relationship. We can deal with any country we wish on a bilateral basis, and, generally speaking, that is the way we do, except for ESA, which is a combination of 10 countries, I believe it is, that we deal with as an entity.

There is nothing to prevent us, though, from dealing directly with West Germany or France.

Mr. MCDADE. But there is no structural effort, apparently—outside of the ESA—to deal with the nations on questions like this.

Dr. LOW. There are two examples. In aeronautics, there is a mechanism through NATO, the North Atlantic Treaty Organization, called AGARD. On commercial ventures, there is the Intelsat consortium, which takes care of the commercial, international satellites.

Mr. MCDADE. Communication satellites?

Dr. Low. That's correct, Mr. McDade.
Mr. McDade. Thank you, Mr. Chairman.

REQUEST TO OMB FOR SPACE TELESCOPE

Mr. Boland. What was your request of OMB for fiscal year 1977 funding for the Space Telescope project?
Dr. Hinners. $12 million.

PROCUREMENT ALTERNATIVES

Mr. Boland. And although no funding is included in the 1977 budget, this committee recognizes that it will be under considerable pressure for funding or for other alternatives. As a matter of fact, the committee is now under pressure from about every conceivable institution that is in astronomy in the United States.

One possibility that has been suggested is that NASA would choose the prime contractor from among the five competing companies.

As you know, the joint conference report on the fiscal year 1976 appropriations bill specifically prohibits NASA from proceeding with any work on this project beyond evaluation of the phase B studies; to pick a prime contractor before any phase C or D funding has been provided would be an extremely unusual procedure.

Could you tell the committee how seriously you are considering that option? Does it require the prior approval of the Office of Management and Budget; and what, if any, are the legal problems?

Dr. Fletcher. Those are good questions, Mr. Chairman.

First, are we considering the option? The answer is yes because we have been asked to consider it by the authorization committees.

Would we have to get OMB approval? I am certain that we would.

As to the legal ramifications, I am not prepared to answer.

Mr. Lilly, have you taken a look at that question yet?

Mr. Lilly. I don't offhand know any legal reasons why we could not, provided that the request for proposals clearly stated that award of a contract would depend upon congressional action. The Government would have no liability except and until money was appropriated and a contract were consumated. I don't know of any other items of a legal nature.

Mr. Boland. Has any opinion been expressed with regard to legal problems?

Dr. Fletcher. No, the general counsel has not expressed any opinion. But we are not far enough along to have asked for an opinion.

SPACE TELESCOPE STUDY CONTRACTOR TEAMS

Mr. Boland. Now, additional concern has been expressed both by you, Dr. Fletcher, and by Dr. Hinners as to how NASA would keep the Space Telescope government-industry team together through the fiscal 1977 hiatus. How many members are involved on that team?

Dr. Fletcher. There are five study contractors involved in that team.

I don't know how many employees each of them has, but we could get that for the record.

[The information follows:]

As of January 1976, the Space Telescope Team was comprised of five contractors, an Instrument Definition Team, and government personnel from the Marshall Space Flight Center and the Goddard Space Flight Center and their support contractor personnel. The number of personnel involved in the Space Telescope as of January 1976 are as follows: an average of 70 personnel each for the three Support Systems Module contractors, and 35 for each of the two Optical Telescope Assembly contractors, making a total of 280 personnel for the five contractors.

The Instrument Definition Team and the scientific working group involved about 40 scientists. The government team was composed of 115 civil service personnel and 20 support contractors.

Mr. BOLAND. Can you keep the team together through 1977 without any additional funding?

Dr. FLETCHER. We are not sure we can do that, Mr. Chairman; and that is one of the problems we are trying to work on. It doesn't look as though it is possible, but I can't say for sure that it is not possible.

OMB POSITION ON SPACE TELESCOPE

Mr. BOLAND. Do you have any assurances from OMB that it will give favorable consideration to any request that you might make for the Space Telescope in September?

Dr. FLETCHER. I think that OMB is favorable, but has not made commitments of any sort.

Mr. LILLY. Mr. Chairman, OMB cannot firmly commit themselves in advance. They did state specifically in their allowance letter to us that the Space Telescope would be considered as a fiscal year 1978 start within the projected estimate of $3.7 billion for fiscal year 1978.

OMB did provide an allowance for fiscal year 1978 new start activities, and the provision is sufficient for the Space Telescope to be one of them.

But in terms of OMB specifically saying that they would favorably consider it, no, they have not.

SPACE TELESCOPE STUDY CONTRACTOR TEAMS

Mr. BOLAND. If the team falls apart, how long does it take to reassemble it? Would this add to the cost?

Dr. HINNERS. I don't think all the teams would fall apart. I think what we would do is be in danger of losing certain of these five contractors as bidders. What it would do is limit our ability to conduct a broad competition. When you lose some of the competition, you may be at the mercy of what is offered by those remaining bidders.

Mr. BOLAND. It would appear to be unusual that you would lose any of the contractors with a project that runs over $400 million.

Dr. FLETCHER. I think the problem, Mr. Chairman, is that we have been funding this at a fairly reasonable level, but the companies have been putting a large amount of their own money in to get ready for competition, which they had hoped would occur this calendar year. And this money means people. And what they are saying, I guess, to themselves is, "Gee, I guess I can't continue to put that kind of money in when I have only got one chance in two or three of winning."

So one or the other of them is likely to drop out and say, "All right, I give up."

If it is only two of the support systems module contractors, then we are in trouble, because then we have only one competitor, and that makes the competition not good.

Mr. BOLAND. If we don't have the Space Telescope the world is not going to come to an end, anyway, is it?

Dr. HINNERS. No, sir.

NATIONAL PRIORITIES

Mr. BOLAND. I think the problem that many members of this subcommittee have with the Space Telescope is basically one of priorities, and I think that is precisely what the position of the administration, perhaps, is. If the Shuttle is going to fly, and I suspect that it will, NASA and the Nation will be entering a new era with a new space transportation resource. The question is, how we make the best use of that research? Time and again Dr. Fletcher and Dr. Low have both stressed the fact that NASA is suffering under a very tight budget. In fact, you pointed out that NASA's budget in real dollars has been consistently dropping. The point is that with less dollars available, all of us recognize the fact—and you do, too, I'm sure—that we have to make the best use of them.

The large Space Telescope is unquestionably a fascinating and interesting project, but it might get up to $500 million. You know we could fund many different application satellites that would have a more immediate pay out, a more immediate economic effect. So it is a question of priorities.

SATELLITE SOLAR POWER SYSTEM

There was an article in the February 9 Aviation Week which discusses NASA's work on a satellite power project. A demonstration model could be built for something on the order of what it costs to do a Skylab. Not only would such a project demonstrate the potential of solar power from space, but it would also be used as a permanent source of sufficient energy for a manned space station or material processing in space or other space activities.

In short, the whole question turns on what priority basis we use the limited number of dollars, and this subcommittee will be looking closely at that question in any consideration for funding of a space telescope.

IMPORTANCE OF SPACE TELESCOPE

Dr. FLETCHER. May I just make one comment?

I don't think the world will fall apart if we don't go ahead with the space telescope, but it is, among NASA and the scientific community, an extremely high priority program. And I think it is important in the long run that we start that program.

Mr. BOLAND. Activities in astronomy won't fall apart, either, will they?

Dr. FLETCHER. It would be a missed opportunity, Mr. Chairman.

Mr. BOLAND. You know, someone said, "What good is it going to do when you get it out there? What does it do? What does it find?"

And somebody says, "More of the same."

Is that correct?

Dr. HINNERS. No, sir. Every time we have gone and looked we find more of the unknown and the new, and we are not going to find more of the same. If we were, I would not waste my time with it. It would not be worth it.

I think when we talk about priorities, we really should face up to the fact that the scientific knowledge and what we are trying to do has an impact on the people in this country, and is as high a priority as these other things we tend to call practical items.

I fail to understand why the acquisition of basic knowledge and the intellectual stimulation are not regarded as applications to the human endeavor.

NATIONAL PRIORITIES

Mr. BOLAND. You make a very persuasive case; but no nation in the history of the world has ever spent the kind of money that this Nation has spent in scientific endeavor; no nation ever will; and no nation, let me say, has accomplished as much, either.

So, you know, when you get complaints from the scientific community—and this subcommittee gets it—not really complaints, but advice and counsel, there has to be a determination on what the priorities are going to be.

When we are spending $3.7 billion for fiscal year 1977, and some projects are eliminated that might be delayed for a while, I just can't understand why suddenly there is a flurry of discontent that we are not doing really what we should do in science activities.

You know, when you look at the record that NASA itself has developed, you can be terribly proud that no nation has done as much, and no nation ever will.

There are some problems here on Earth which we have to be concerned about, and they are difficult ones. If we don't solve those, there won't be any money for space applications or space technology or space science.

Mr. ROUSH. Mr. Chairman?

Mr. BOLAND. Yes, Mr. Roush.

Mr. ROUSH. Does it have to be a question just between $12 million and no dollars for this project?

Dr. FLETCHER. Mr. Roush, the problem, I think, is simply that we are in a very tightly constrained budget year. Every $12 million counts, and since this is not a time-critical program, as the chairman has indicated, we thought it was a wise thing to do to defer it for consideration in the fiscal year 1978 budget process.

DISCOVERIES IN ASTRONOMY

Mr. TALCOTT. Is there anything to be said for astronomy being one of the burgeoning sciences?

You know, we have had different interests in different sciences through the ages. A number of universities are developing new courses, and new telescopes being developed by you and by the National Science Foundation, by universities, by private people. There seems to be a burgeoning effort in astronomy.

Dr. HINNERS. Yes. It goes hand in hand with the technology. A big burst in astronomical discovery took place when we were able to get above the atmosphere and do away with the feeling of the atmosphere interference. We think we are approaching another breakthrough in the area of the equipment, the experiments and the detector systems that let us, essentially, look at single photons of light, single X-rays and gamma rays and find out where they come from.

So, yes, I think it is a step function, that our technology has taken us to a point where we can take advantage of it and make discoveries.

PRIORITIES AND TIMING

Mr. BOLAND. This committee, as you know, funds the National Science Foundation, and we are providing somewhere in the neighborhood of $80 million for the very large array (VLA).

When you get a look at what this committee funds and what the Congress funds and what the administration spends on basic science with NSF and NASA and other agencies, it amounts to a considerable sum.

So it is not as if we weren't doing anything in this area, because the Nation is doing quite a bit, and the taxpayers are picking up a hefty tab on it.

Again, it is a problem of where you put the dollars when the times are lean and when the dollars are becoming a little more difficult to come by.

But you have made your judgments. You apparently agree with the administration on this.

Dr. FLETCHER. Yes, I think so in terms of this fiscal year, Mr. Chairman. It is a major step forward and it is a sizable amount.

By the way, it is $400 million and not $500 million. And we hope to make it even less, if we can.

Mr. BOLAND. GAO said $445 million.

Dr. FLETCHER. The space telescope will be a major advance in knowledge. It is like a large accelerator, or any key advance. It will be a brand-new observational facility with capabilities this country has never had before, and I think it needs debate such as we have been having before you start it.

This year did not seem the right year to start the project.

Mr. BOLAND. I think it is, as I indicated, a subject which is now very controversial.

But in any event, we will stop here. We will adjourn until 9 o'clock in the morning and we will see if we can complete the hearings tomorrow.

Mr. TALCOTT. Mr. Chairman, I have some questions.

Mr. BOLAND. Would you like to ask them?

Mr. TALCOTT. No. I will submit them for the record.

[The questions and answers follow:]

Question 1. Dr. Fletcher, near the bottom of the first page of your testimony you state that the fiscal year 1978 estimate is "essentially" identical with the total request for fiscal year 1977, but does not include allowances for inflation beyond fiscal year 1977.

Can you tell the committee why this decision was made, and what you feel a proper estimate of the impact of inflation beyond fiscal year 1977 should be?

Answer. Provision for inflation was excluded from the fiscal year 1978 and budget runout estimates based on OMB budget guidelines. However, since NASA projects are highly labor intensive, we closely watch wage and benefits—compensation—growth indicators and trends. Our analysis of factors such as: aerospace wage and benefit forward pricing rates; forecasts such as compensation per man-hour—total private; and current trend setting major collective bargaining settlements; indicates continued significant labor cost growth in the future. Another important factor is that aerospace union agreements include cost-of-living adjustment formulas keyed to the Consumer Price Index (CPI). Current forecasts of CPI growth are about 6 percent for fiscal year 1978 which would mean a union

wage cost-of-living increase of about 4.8 percent on top of the general increases. These union increases in turn directly influence other professional and nonprofessional compensation levels in the aerospace industry. Some of the indicators we have of the inflation impact through 1980 are displayed below; based on these trends an annual rate of around 7 percent would seem reasonable for R. & D. activities.

[In percent; fiscal years]

	1978	1979	1980
Aerospace forward pricing (compensation) survey	7.7		
Compensation per man-hour (total private) forecast by Data Resources, Inc. (DRI)	7.6	7.8	8.0
Major collective bargaining settlements, wages and benefits over life of contract (BLS)	8.0		
NASA R. & D. inflation projected on basis of historic relationship with CPI using DRI CPI forecast	7.6	7.2	7.0

Question 2. On page 7 of your statement I notice that you state that the fiscal year 1977 budget contains no request for continued direct R. & D. funding for terrestrial research in energy. I looked in the ERDA budget to see if your current program, which I believe is running about the $8.5 million level, had been transferred. I couldn't seem to find any item which indicated that there had been a transfer. Can you tell us what happened to that effort?

Answer. The NASA fiscal year 1977 budget does not request any R. & D. funding for energy programs. This reflects a recent policy decision by the administration that such direct funding will be provided by ERDA. Because this decision was made in late December, there was insufficient time for ERDA to include specific provisions for NASA energy R. & D. funding in the ERDA fiscal year 1977 budget. However, we have been discussing this problem with ERDA management and expect that it will be possible to arrange for an appropriate allowance for funding this effort.

Question 3. Last year at the time of the emergency employment appropriations bill we had a very interesting discussion of the long- and short-term economic benefits resulting from R. & D. developments.

This year I am concerned to note that R. & D. is up about 12 percent overall, but is only up 4 percent in your budget. Would you be kind enough to bring the committee up to date on what the latest figures are with respect to the economic benefits of each dollar invested in R. & D.?

Answer.

ECONOMIC IMPACT OF NASA PROGRAMS

Funding for NASA programs benefits the economy in several ways:

Direct benefits accrue from application of space technology to needs on Earth. Communications, weather prediction, and navigation are examples of widespread everyday use of space capabilities. Earth resources data from space is increasingly used with economic benefits. New and expanded uses of space are being developed.

The space programs provide a major stimulant to growth in high technology areas. These technological advances lead to new capabilities, new products, and increased productivity in the U.S. economy.

The United States enjoys a large favorable balance of trade in the aerospace industry. This favorable balance results largely from sales of aircraft, engines, parts, and related items, but we also have a favorable balance in space elements including spacecraft, launch services, and communications.

Employment is stimulated by NASA programs in both the long and short term. Much of the employment generated is of the type that encourages development of the skills and capabilities of the workers and uses existing industrial capacity which is currently underutilized.

In the short run, NASA expenditures have a very direct effect on employment:

(1) NASA expenditures are labor intensive. About 85 percent of NASA spending goes directly to jobs. Only about 15 percent goes for materials.

(2) Increases in NASA spending will not be inflationary at this time because there is now underemployment and unused plant capacity in the aerospace industry.

(3) Every $100 million of NASA spending is the equivalent of about 4,000 direct jobs per year.

(4) The multiplier effect of additional jobs created indirectly in the community and the economy at large is significant and brings the total jobs resulting from each $100 million of expenditures up to about 10,000 jobs.

In the long run, the economic impact of NASA's expenditures is to increase productivity, both through direct applications of aeronautical and space technology—as demonstrated by communications satellites, improved aircraft, et cetera—and indirectly through the development and dissemination of advanced technology which is then applied in many other sectors of the economy. Independent studies have shown that NASA's high technology expenditures yield a high rate of return. Broad scale studies indicate a return over a period of years of about $7 for every $1 of NASA expenditures. Separate studies have shown significant benefits from productivity increases in specific areas of cryogens, integrated circuits, gas turbines, and automated structural analysis. In the long run, these economic benefits lead to corresponding increases in job opportunities.

In summary, expenditures for NASA programs stimulate employment in the near term and provide a technology stimulant leading to long-term growth of the economy and of employment opportunities.

Question 4. We have seen a number of newspaper reports about the proposed exposition to be held this summer at Cape Canaveral, which I believe is a joint effort with the Department of Commerce. Could you tell us about that, and explain how it will be funded?

Answer. The U.S. Bicentennial Exposition of Science and Technology has been conceived and designed to focus attention on the present and future. The event will celebrate the American state of the art in science and technology today and its prospects during our next 100 years. The overall theme of the exposition is "A Better Life in Third Century America."

The exposition will open May 30, 1976, and run through Labor Day of the Bicentennial Year at the Kennedy Space Center. With the visually dramatic space facilities as backdrop and exhibitry, the exposition can provide a meaningful vision of the future. The complex also demonstrates that technology and nature can coexist in harmony.

The idea for the exposition was born as a result of a regular review of Bicentennial preparations by the White House staff. A report was developed early last spring and resulted in a recommendation for a science and technology exposition at Cape Canaveral which would address itself to the progress and contributions made to date in this field and what contributions can be expected in the third century.

After final review and consideration in the summer of 1975, planning for the exposition was initiated.

The National Aeronautics and Space Administration was designated as lead Government agency and an interagency steering committee was established to coordinate the Government's participation in the exposition.

It is expected that about 16 Government agencies will participate by furnishing agency exhibits. These exhibits, their transportation to and from the site, and the necessary staffing and operations will be funded by each participating agency.

Industry exhibitors will pay rental on a square foot basis for covered exhibit space as well as pay for any special service requirement expenses.

Three million dollars has been provided NASA from the Department of Commerce's job opportunities program (title X) by the Economic Development Administration for construction of necessary facilities and for site development. It is expected that direct operating costs will be met by admission fees and revenue from food and souvenir sales. Attendance is anticipated to be at least 8,000 people per day.

The parking lot areas adjacent to the vehicle assembly building (VAB) at the Kennedy Space Center will be used for the exposition site. Fifteen geodesic domes are being erected on the site to provide undercover space for the various participants' exhibits. There will also be outdoor exhibit space available as well. Exhibits will also continue to be displayed at the existing visitor information center. There will be various visitor services in the form of food, souvenir, and sanitation facilities.

Some of the exhibitry will become a permanent feature of the regular NASA tours at Kennedy Space Center. While the exposition is going on, the Space Shuttle and various unmanned scientific and technological programs will continue without interruption.

The exhibitors will all be American. The idea is to celebrate American advancements in science and technology as well as to recognize and renew our pride in past accomplishments and future endeavors.

Individual exhibits will emphasize the way our scientific discoveries, inventions, and choices for alternative futures affect the way Americans are going to live, work, play, and be educated in the years ahead. An important point of the exposition should be to show how technology can help solve problems as well as contribute to them.

Question 5. In connection with the cape project, can you tell us briefly, and amplify for the record if you want, what are your Bicentennial efforts for this year?

Answer. While NASA is only 1 of 16 Government agencies and about a dozen private companies involved in the exposition, it is also the host for the exposition and manages the site and the 15 geodesic domes which will house most of the exhibitry. The NASA participation in the exposition will involve the use of vehicle assembly building (VAB) space, outside exhibits, and continued operation of the existing visitors information center and the tours conducted therefrom.

Perhaps the most exciting NASA exhibit is the mammoth vehicle assembly building itself where the rockets were assembled before propelling American astronauts on their historic voyages to the Moon, and which will now be used in the Space Shuttle program.

NASA exhibits inside the VAB planned to be provided by several NASA centers will include: a Viking diorama with a full-scale Viking lander; a full-scale ASTP mockup; an aeronautics display tracing the history of flight from the Wright Brothers, and projecting technology into the aircraft of tomorrow; a shuttle exhibit is being completed by JSC, and will complement the one-third scale shuttle being exhibited by industry; a future of space exhibit; a lunar landscape; a technology utilization exhibit; a planetary exhibit, showing spacecraft models and photos of planets taken by spacecraft; and an applications exhibit, including a giant photo of Earth taken by LANDSAT, plus weather and other photos used daily for applications here on Earth.

It is planned that an actual firing room in the VAB will be used to provide simulations of Saturn launches to the Moon for the public to witness. It is also planned to provide an activities room in the VAB featuring displays where children can pose for pictures while participating in displays such as scales to show them how much they would weigh on the Moon or some of the planets; a lunar module trainer that they can operate; and a swing arm leading into a white room—just like the one the astronauts crossed when getting into their spacecraft. There will be an array of space suits and other equipment they can try on and even consoles they can operate.

Outside the VAB, a Saturn V rocket will be exhibited as will the crawler, the launch umbilical tower and other facilities. Aside from these projected exhibits and hardware displays, the NASA tours from the existing visitors information center at the Kennedy Space Center will include the astronaut flight crew training facilities as a new feature, and will, of course, continue to take visitors to the launch sites and other space-age places of interest.

The visitors information center is also being provided with some new exhibits.

Question 6. "Dr. Fletcher, I can understand the distress of the scientific community to have lost the opportunity to launch Mariner Jupiter/Uranus (MJU) during the launch window in the late 1970's. Did I understand that the unique alinement of the planets will not occur for about another 84 years?"

Answer. The 1979 Jupiter/Uranus launch opportunity was unique in two respects. Jupiter and Uranus were alined in such a way that a near encounter with Jupiter would accelerate the spacecraft toward Uranus thereby allowing shorter trip time and higher probability of success. Secondly, the orientation of Uranus at the time of encounter would have been with the pole of Uranus pointed toward the Sun. This solar orientation—unique in the solar system—could provide valuable information about the interaction between the Sun and the planet's atmosphere and magnetosphere, yielding new basic insight into Sun-planet interactions, and therefore promising to increase our understanding of the Earth's magnetosphere and weather patterns.

There is an opportunity to go to Uranus via Jupiter every 14 years (1979, 1993, 2007, 2021); however, the unique polar orientation of Uranus occurs only once every 42 years. Thus, the next opportunity to perform an equivalent mission will occur in 2021—42 years after the 1979 opportunity. The 84-year peri-

odicity to which you refer is the time required for the "north pole" to return to the same orientation—our scientific advisers have indicated that observations of either the "North" or the "South" pole are equally valuable, hence the 42-year periodicity that I indicated.

I would like to point out that, although we were not able to proceed with a new start for the Mariner Jupiter/Uranus (MJU) mission, we do plan to retain an option to retarget our second Mariner Jupiter/Saturn (MJS) spacecraft, prior to its Saturn encounter, to go on to Uranus if the spacecraft is healthy and we have adequately satisfied our objectives at Saturn with the first encounter. This spacecraft would arrive at Saturn about 4 years after launch and at Uranus about 8 years after launch—at this time Uranus would have the unique pole-on orientation.

Question 7. "I assume that you are able to accurately predict when these unique launch opportunities will come up. Can you give us a list of those which occur over the next 25 years, and explain the value of each? You may amplify for the record if necessary."

Answer. In principle, there are relatively frequent opportunities to send spacecraft to the various planets: opportunities to send spacecraft to Mercury recur every few months; opportunities to send spacecraft to Mars recur every 26 months; and opportunities to send spacecraft to the other planets recur somewhere between these two extremes. If a hypothetical launch vehicle of ultrahigh performance and low cost were available, the uniqueness of launch opportunities would not be a major concern. In fact, because of launch vehicle limitations, it is virtually impossible to send spacecraft directly to Mercury or to the planets beyond Jupiter.

An ingenious technique has been perfected by NASA's Jet Propulsion Laboratory that utilizes a flyby of an intermediate planet to impart the additional energy that is required to reach a more distant planet: for example, a Venus flyby can be used to send a spacecraft to Mercury as was the case with the 1973 Mariner Venus/Mercury mission or a Jupiter flyby can be used to send a spacecraft to Saturn and beyond as is the case with Pioneer 11. However, this technique is not without its drawbacks: the target planet and all the intermediate planets must be properly alined—a relatively infrequent occurrence. As an example, from 1977 to 1979, the planets Earth, Jupiter, Saturn, Uranus, and Neptune will be so uniquely alined that it would have been possible for a single spacecraft to visit four outer planets—this is the so-called grand tour. The alinement could also have been used to send a spacecraft from Earth to Jupiter, Saturn, and then on to Pluto. This unique alinement last occurred during the Presidency of Thomas Jefferson and will next occur in 2157.

In addition to these planetary opportunities that are unique because of planetary alinement, there are opportunities to investigate comets and asteroids that are unique because the bodies infrequently come into nearby regions of the solar system.

Barring radical improvements in propulsion technology, the following launch opportunities are unique in the sense that they recur very infrequently.

There is a very good opportunity in 1977 to send a Mariner-class from Earth to Jupiter, Saturn, and on to Pluto. A more modest mission—the Mariner Jupiter/Saturn mission—was approved by the Congress in fiscal year 1972. The two Mariner spacecraft to be launched in 1977 will reach Jupiter approximately 2 years after launch and will reach Saturn in an additional 1½–2 years. If the first spacecraft achieves its objectives and if the second spacecraft is operating properly when it reaches Saturn, the latter's encounter at Saturn can be modified so that the spacecraft proceeds to Uranus. The next opportunity to reach Saturn via Jupiter will be in 1998; the next opportunity to reach Uranus via both Jupiter and Saturn will be 2117.

There is a very good opportunity in 1979 to send a Mariner-class spacecraft to Uranus via Jupiter. This opportunity was the basis of the Mariner Jupiter/Uranus mission (MJU 1979) that NASA unfortunately had to forgo. The flight time to Uranus for the MJU spacecraft would have been approximately 5½ years as opposed to the 8 years that would be required for the MJS spacecraft to reach Uranus; therefore, the chance of obtaining data at Uranus would have been greater for MJU than it is for MJS. An additional advantage of the MJU mission is that its payload would have been optimized for gathering science at Uranus. The next opportunity to reach Uranus via Jupiter will be 1994. However, the pole-on Uranus configuration that is so scientifically unique will not recur until 2022.

There are also several opportunities during the mid-1980's to send spacecraft to Uranus via Saturn; however, the energy requirements are higher. These opportunities will not recur until 2028.

There is an opportunity in 1993 to send a spacecraft to Neptune via Jupiter. Similarly, there are opportunities in 1990 and 2002 to send spacecraft to Pluto via Jupiter.

Halley's Comet, the most spectacular and famous of the comets, will return in 1985 after an absence of 76 years. It will be possible to launch a spacecraft in 1985 that would encounter Halley and make detailed observations of its composition and structure. The next opportunity to visit Halley will be in 2061.

Finally, an asteroid called "1976 AA" has just been discovered in the vicinity of the Earth. This asteroid will again be close to the Earth in 1996 and it should be possible for a spacecraft to rendezvous with it in order to make detailed observations and, possibly, to return a sample to Earth.

The alinement of the planets is, more often than not, the reason that an opportunity is unique; however, it is also possible for technological advances and for certain space hardware to provide unique opportunities. If nuclear electric propulsion were now available, it would have been possible for a spacecraft to rendezvous with Halley's Comet and to make numerous closeup observations over an extended period of time; this would have been far superior to the fast flyby mission that we are now considering. In a sense, the lack of technology has precluded the opportunity to take full advantage of a relatively unique occurrence.

Question 8. Dr. Fletcher, I have long been a believer that NASA has one of the best systems of organization and performance in government. I guess that you must be doing a good job still, because I heard recently that Senator Proxmire, who loves to find inefficiencies anywhere in government, went so far as to publicly compliment you. For that you have my congratulations, those who have been complimented by the Senator are as few as the Republicans on this side of the table. In fact, I would like to see both numbers increase dramatically.

In any case, I know that you conduct a continuing review of both work assignments and work performance standards. Would you take a few moments and give the committee an overview of how you do this, and in particular, can you explain how you justify individual positions and set work performance standards?

Answer. Position management is the methods, techniques, and processes by which management evaluates the need for positions and assures the effectiveness of position and organizational structure. The fundamental objective of NASA's position management program is to make optimum use of its manpower resources by designing positions for the best possible balance among the competing forces of mission objectives, manpower availability, efficiency, skills utilization, employee challenge, and employee growth and development. This is almost always a compromise solution since the demands of each factor are different, are often in conflict, change frequently in urgency and emphasis, and are limited by laws, regulations, and resources.

The NASA management issuance setting forth the objectives and minimum requirements of position management in the agency is attached. In addition, the headquarters sets and monitors controls on average grade and manpower strength for each installation on a fiscal year basis. These controls, objectives, and minimum requirements provide the framework within which each NASA installation must manage its human resources.

PROCEDURES AND PROCESSES

Installations

In order to fulfill these responsibilities each installation has devised its own detailed position management procedures and processes compatible with its management style and operating functions. While some differences in approach exist among the various installations, a common core of activities is in operation at each. These include:

(*a*) *Manpower ceiling control.*—Attrition is the primary vehicle for achieving/maintaining approved manpower strength levels. When an organization loses personnel, the vacated space cannot be filled until replacement hiring is approved. The replacement approval process involves the development of a full justification; review, comment, and recommendations on justifications by staff offices such as personnel, budget, planning, management analysis; approval or disapproval at a top management level.

(*b*) *Average grade control.*—Restrictions on promotions and emphasis on entry-level hiring are the primary means for achieving/maintaining approved average grade levels. Promotion and hiring capability is computed several times each year based on the projected grade average of attrition and entry-level hiring as compared to the average grade target. Promotion and hiring allocations resulting from these calculations are distributed among organizations with the approval of the Center Director or Deputy Director in most cases.

(*c*) *Promotion control.*—The number of promotions allowed depends upon the promotion allocation resulting from the average grade level computation. However, within these allocations controls exist to assure compliance with law and regulation and consideration of deserving employees. Promotion proposals emanate from the lowest supervisory levels, and through a review and elimination process at succeeding organizational levels, each major organizational entity determines a promotion priority list. Concurrent with this activity the personnel office advises on and assures compliance with civil service requirements including position classification standards. The final selections for promotion are generally made by manpower utilization committees staffed by top management and staff support officials. At a few installations the Center Director personally approves all promotions, and at others the Director approves promotions above the GS–13 grade level. At all installations promotion activities are designed to focus senior management attention on this important human resource management endeavor.

(*d*) *Position need and structure control.*—While substantial variety exists among installations as to the specific combinations of procedures and processes employed in controlling the need for and structure of positions, they all involve the following: Top management level attention; personnel specialist advice on, and review of, the occupational mix among positions, and the skill mix content of positions; periodic review of all positions by management and personnel specialists for need and srtucture; and reassessment of the need for all vacated positions in terms of organizational needs and occupational and skills mix.

(*e*) *Position classification accuracy control.*—Two basic procedures are in operation at all installations to assure the continuing conformance of position classifications with applicable Civil Service Standards and regulations. Annually, all positions are reviewed to assure compliance with standards and regulations. These reviews are conducted jointly by personnel specialists and management and include onsite position audits in addition to documentation reviews. In addition, on individual position actions, personnel specalists advise managers on position structuring and documentation and determine the appropriate civil service title and grade.

Headquarters

On a coordinated basis, the headquarters offices functionally responsible for the various aspects of agency position management establish agency-level requirements and evaluate installation performance. Ongoing overview is accomplished through formal reporting systems which show grade level distribution, occupational mix, supervisory ratios, and average grades. Changes to basic organizational structures require headquarters approval as do all actions involving executive-level positions.

In addition to the day-to-day monitoring of position management activities throughout the agency, periodic onsite reviews are made to assess position structure, position classification accuracy, and the effectiveness of position management processes and procedures. The most recent review of this type was conducted at all installations during May, June, and July 1975, as part of an overall evaluation of personnel management effectiveness. The findings have been compiled and analyzed, and a report including recommended actions has been prepared for the Administrator.

Question 9. Dr. Fletcher, I note that you have deferred funding requests for work which has been authorized on the 40 x 80-foot subsonic wind tunnel at Ames Research Center. I also sit on the Military Construction Subcommittee, and we have a pending request for funding for an Aeropropulsion Systems Test Facility (ASTF) to be located at the Arnold Engineering Test Center in Tennessee. There is substantial concern that test facilities may be duplications or unnecessary.

(*a*) What wind tunnel test facilities are now available to NASA, DOD and other Federal agencies? (Both federally owned and private)

Answer.

SUMMARY OF GOVERNMENT-OWNED WIND TUNNELS

1. References

An Inventory of Aeronautical Ground Research Facilities, volume I, NASA CR–1874, prepared under Contract No. NAS 2–5458 by McDonnell Aircraft Co. for NASA headquarters, November 1971.

Technical Facilities Catalog, National Aeronautics and Space Administration, NHB 8800.5A October 1974.

2. Introduction

The following is a summary of Government-owned wind tunnels developed from a survey of available data compiled from the above references.

For the purposes of this report, coverage of the wind tunnel facilities was largely size limited. In general, subsonic wind tunnels having tests sections greater than 5 feet plus 5 feet were included, as well as transonic/supersonic tunnels greater than 2 feet plus 2 feet and supersonic tunnels greater than 1 foot plus 1 foot. Included, however, are a few facilities which do not strictly adhere to these minimum sizes, but are of special interest either because of their unique capabilities or they represent the major wind tunnel capability of the reporting installation.

The summary of wind tunnel facilities is arranged in the four major facility categories: (1) subsonic, (2) transonic, (3) supersonic, and (4) hypersonic. Those facilities meeting the criteria of more than one category are included under that category best describing the facilities capabilities.

3. Wind tunnel summary

Organization/location	Facility name	Test section size (height, width, length) (feet)	Mach range
A. SUBSONIC TUNNELS			
Air Force Flight-Dynamics Laboratory, Wright-Patterson AFB, Ohio.	Vertical wind tunnel	12 ft long	0 to 0.14.
Air Force Institute of Technology, Wright-Patterson AFB, Ohio.	5 ft subsonic wind tunnel	5 ft diameter × 18 ft length.	0 to 0.35.
NASA Ames Research Center, Moffett Field, Calif.	40 ft by 80 ft subsonic wind tunnel.	40 ft×80 ft	0 to 0.3.
Do	7 ft by 10 ft subsonic wind tunnel No 1.	7 ft×10 ft×15 ft	0 to 0.33.
Do	7 ft by 10 ft subsonic wind tunnel No. 2.	do	0 to 0.34.
Do	12 ft pressure tunnel	11.3 ft diameter× 18 ft length.	0 to 0.98.
NASA Langley Research Center, Hampton, Va.	Full scale tunnel	30 ft×60 ft×56 ft	25 to 110 mph
Do	V/STOL transition research wind tunnel.	14.5 ft×21.75 ft ×50 ft.	0 to 0.32.
Do	High speed 7 ft×10 ft tunnel	6.6 ft×9.6 ft×10 ft	0.2 to 0.9.
Do	Low-turbulence pressure tunnel.	7.5 ft×3 ft×7.2 ft	0.1 to 0.4.
Do	Spin tunnel	25 ft×20 ft	0 to 90 ft/s.
NASA Lewis Research Center, Cleveland, Ohio.	Icing research tunnel	6 ft×9 ft×20 ft	0 to 0.55.
Do	9 ft×15 ft V/STOL wind tunnel.	9 ft×15 ft	0 to 0.85.
National Bureau of Standards, Gaithersburg, Md.	Dual test section subsonic wind tunnel.	4 ft × 5 ft × 8 ft; 7 ft × 5 ft × 40 ft.	0 to 0.2, 0 to 0.15.
Naval Ship Research and Development Center, Washington, D.C.	8 ft by 10 ft subsonic wind tunnels, Nos. 1 and 2.	8 ft × 10 ft × 14.2 ft; 8 × 10 ft × 14.2 ft.	0 to 0.29, 0 to 0.25.
Fairbanks Highway Research Station, Department of Transportation, McLean, Va.	Bureau of Public Roads, wind tunnel.	6 ft × 6 ft	40 fps
Fluid Dynamics and Diffusion Laboratory, Colorado State University, Fort Collins, Colo.	Army meteorological wind tunnel.	do	120 fps
Erosion Laboratory, Department of Agriculture, Manhattan, Kans.	Laboratory wind tunnel.	5 ft × 8 ft	75 fps
Naval Weapons Industrial Research, Dallas, Tex. (operated by LTV Aerospace Corp.).	Low speed wind tunnels.	7 ft × 10 ft; 15 ft × 20 ft.	0.3 to 0.36, 0.0063 to 0.069.
Naval Weapons Industrial Research, Columbus, Ohio (operated by North American Rockwell).	Subsonic wind tunnels	7 ft × 10 ft; 16 ft × 14 ft.	0 to 0.37, 20 to 80 mph
Northern Forest Fire Laboratory, Department of Agriculture, Missoula, Mont.	Wind tunnel	10 ft × 10 ft	12 fps

Organization/location	Facility name	Test section size (height, width, length) (feet)	Mach range
B. TRANSONIC TUNNELS			
Arnold Engineering Development Center, Arnold Air Force Station, Tenn.	16 ft transonic	16 ft × 16 ft × 40 ft.	0.2 to 1.6.
Do	4 ft transonic	4 ft×4 ft×12.5 ft	Unk.-1.3.
NASA Ames Research Center, Moffett Field, Calif.	14 ft transonic tunnel	13.5 ft×13.9 ft	0.6 to 1.2.
Do	6 ft by 6 ft supersonic wind tunnel.	6 ft×6 ft×14 ft	0.25 to 2.2.
Do	2 ft by 2 ft transonic wind tunnel.	2 ft×2 ft×5 ft	0.6 to 1.4.
NASA Langley Research Center, Hampton, Va	Transonic dynamics tunnel	16 ft×16 ft×30 ft	0 to 1.2.
Do	16 ft transonic tunnel	15.5 ft octogonal	0.2 to 1.3.
Do	8 ft transonic pressure tunnel	7.1 ft×7.1 ft×18 ft	0.2 to 0.3.
Do	1/3 meter cryogenic tunnel	13.5 ft octagonal	0.5 to 1.3.
Naval Ship Research and Development Center, Washington, D.C.	7 ft by 10 ft transonic wind tunnel.	7 ft×10 ft×19 ft	0.4 to 1.17.
Naval Weapons Industrial Research, Columbus, Ohio (operated by North American Rockwell).	Supersonic/transonic wind tunnel.	2.17 ft×2.17 ft	0.3 to 3.0.
C. SUPERSONIC TUNNELS			
Arnold Engineering Development Center, Arnold Air Force Station, Tenn.	16 ft supersonic-16S	16 ft×16 ft×40 ft	1.5 to 4.75.
Do	Supersonic wind tunnel (A)	3.33 ft x 3.33 ft x 7 ft	1.5 to 6.
Air Force Flight Dynamics Laboratory, Wright-Patterson AFB, Ohio.	2 ft supersonic gas dynamic facility	2 ft x 2 ft	1.5, 1.89, 2.3, 3, 4.76
Ballistic Research Laboratory, Aberdeen Proving Ground, Md.	Supersonic wind tunnel No. 1	1.25 ft x 1.08 ft	1.25 to 5.
Do	Supersonic wind tunnel No. 3	1.67 ft x 1.25 ft	1.15 to 4.89.
NASA Ames Research Center, Moffett Field, Calif.	Unitary wind tunnel	11 ft x 11 ft, 9 ft x 7 ft, 8 ft x 7 ft	0.5 to 1.4, 1.55 to 2.55, 2.4–3.5.
NASA Langley Research Center, Hampton, Va	9 ft by 6 ft thermal structures tunnel.	8.75 ft x 6 ft x 10 ft	3.
Do	Unitary plan wind tunnel	4 ft x 4 ft x 7 ft, 4 ft x 4 ft x 7 ft	1.47 to 2.86, 2.29 to 4.63
Do	4 ft by 4 ft supersonic pressure tunnel.	4.5 ft x 4.5 ft x 7 ft	1.25 to 2.6
NASA Lewis Research Center, Cleveland, Ohio	10 ft by 10 ft supersonic wind tunnel.	10 ft x 10 ft x 40 ft	2 to 2.35.
Do	8 ft by 6 ft supersonic wind tunnel.	8 ft x 6 ft x 39 ft	0.8 to 2.1.
Naval Ordnance Laboratory, Silver Spring, Md	Supersonic tunnel No.1	1.33 ft x 1.33 ft x 5 ft	0.05 to 9.
Do	Supersonic tunnel No. 2	do	1.5 to 5.
Do	Boundary layer channel	1 ft x 1 ft x 5 ft	3, 5.
Naval Ship Research and Development Center, Washington, D.C.	18-in by 18-in supersonic wind tunnel.	1.5 ft x 1.5 ft x 2 ft	0.2 to 0.9, 1.56 to 4.5.
U.S. Air Force (operated by Goodyear Aerospace Corp., Akron, Ohio).		4 ft diameter	3.
D. HYPERSONIC TUNNELS			
Arnold Engineering Development Center, Arnold Air Force Station, Tenn.	Hypersonic wind tunnel (B)	50 in diameter	6, 8.
Do	Hypersonic wind tunnel (C)	50 in diameter	10, 12.
Do	Hypersonic wind tunnel (E)	12 in high x 12 in wide	8.
Do	Hypervelocity wind tunnel (F)	100 in diameter	22.
Do	Hypervelocity wind tunnel (H)	50 in diameter	20.
Do	Hpervelocity wind tunnel (I)	Not available	Not available.
Do	Hypervelocity wind tunnel (J)	do	Do.
Do	Low density hypersonic wind tunnel (L).	48 in diameter	3.7 to 16.1.
Do	Low density hypersonic wind tunnel (M).	10 in diameter	16 to 22.
Air Force Aero Propulsion Laboratory, Wright-Patterson AFB, Ohio.	Ramjet research-10 ft shock tunnel.	120 in diameter	8 to 33.
Do	50-MW gasdynamic facility.	96 in diameter	5.5 to 15.
Do	2-ft electrogasdynamic facility.	19.36 in diameter	6 to 12.
Do	High temperature hypersonic wind tunnel.	32 in diameter	8.5 to 11.5.
Aerospace Research Laboratory, Wright-Patterson AFB, Ohio.	30 in hypersonic wind tunnel	30 in diameter	16 to 22.
Do	20 in hypersonic wind tunnel	20 in diameter	12, 14.
U.S. Air Force Academy, Colorado Springs, Colo.	Hypersonic shock tube	17 in diameter	12.
U.S. Air Force (operated by Cornell Aeronautical Laboratory, Inc., Buffalo, N.Y.).	Wave superheater hypersonic tunnel.	20 in diameter	14.
U.S. Air Force (operated by Marquandt Corp., Van Nuys, Calif.).	Gas dynamics laboratory	24 in diameter	20.
U.S. Air Force (operated by Polytechnic Institute, Brooklyn, Farmingdale, N.Y.).		24 in diameter	8.
U.S. Air Force (operated by Rensselear Polytechnic Institute, Troy, N.Y.).	Low density hypersonic shock tunnel.	24 in diameter	25.

Organization/location	Facility name	Test section size (height, width, length) (feet)	Mach range
U.S. Air Force (operated by General Applied Science Laboratory, Westbury, N.Y.).	Horizontal pebble heater	24 in diameter	6.
Do	Vertical pebble bed heater	25 in diameter	25.
Do	HYAC	30 in diameter	12.
Do	6000 PSI facility	30 in diameter	12.
Do	Shock tunnel	42 in diameter	20.
U.S. Air Force (operated by General Electric Co., Valley Forge, Pa.).	2—22 in hypersonic shock tunnel.	30 in diameter	20.
Do	2—30 in hypersonic shock tunnel.	42 in diameter	25.
Do	6—54 in hypersonic shock tunnel.	72 in diameter	20.
U.S. Air Force (operated by AVCO Corp., Wilmington, Mass.).	20 in shock tunnel	20 in diameter	16.
Do	33 in shock tunnel	32 in diameter	9.8.
U.S. Air Force (operated by Aerospace Corp., El Segundo.	High Reynolds number facility	24 in diameter	7.
Ballistic Research Laboratory, Aberdeen Proving Ground, Md.	Hypersonic wind tunnel No. 4	15 in diameter	6, 7.5, 9 2.
NASA Ames Research Center, Moffett Field, Calif.	3.5 ft hypersonic wind tunnel	42 in diameter	5, 7, 10, 14.
Do	30 in electric arc shock tunnel	30 in high x 30 in width x 36 in long	8.5 to 19.7.
Do	High Reynolds No. tunnel	20 in diameter	8, 15, 20, 26.
Do	Entry—Aerodynamics and heat transfer tunnels.	24 in diameter	8.5 to 14.
Do	Hypervelocity free flight facility.	42 in diameter	30 K ft/s (model speed).
NASA—Jet Propulsion Laboratory, Pasadena, Calif.	43 in sock tunnel	43 in diameter	12.5
Do	21 in hypersonic wind tunnel	21 in high x 20 in wide x 70 in long	4 to 11.3.
NASA Langley Research Center, Hampton, Va.	8 ft high temperature structures tunnel.	96	6 to 7.5.
Do	High Reynolds number helium tunnels.	60, 37	20, 10.
Do	Scram jet tunnel	11 in x 12 in	6.
Do	Continuous flow hypersonic tunnel.	31 in high x 31 in wide x 72 in long	10, 11, 12.
Do	22 in helium tunnel	22.5 in diameter	17.6 to 22.2.
Do	20 in hypersonic CF_4	20 in diameter	6.
Do	20 in hypersonic tunnel (mach 6).	20 in high x 20 in wide.	6.
Do	Hypersonic nitrogen tunnel	19 in diameter	19.
Do	Mach 8 variable density hypersonic tunnel.	18 in diameter	7.5 to 8.
Do	Open jet helium tunnel	30 in; 22 in diameter	20; 40.
Do	Mach 6 high reynolds number tunnel.	12 in diameter	6.
Do	Hot gas radiation research facility.	11 in diameter	25 k to 50 k ft/s.
Do	Entry structures facility	2 to 3 specimen diameter.	
NASA, Lyndon B. Johnson Space Center, Houston, Tex.	10-megawatt arc tunnel facility.	25 in diameter	2 to 8.
Do	1.5-megawatt arc tunnel facility.	6 in diameter	4 to 5.
Naval Ordnance Laboratory, Silver Spring, Md	Hypersonic wind tunnel	18 in diameter	5, 6, 7, 8, 9, 10 12, 17.
Do	3-megawatt arc tunnel	10 in diameter	1 to 10.
Naval Ship Research and Development Center, Washington, D.C.	13.5 in hypersonic wind tunnel	13.5 in diameter	5 to 10.
Atomic Energy Commission, Albuquerque, N. Mex.	Hypersonic wind tunnel	18 in diameter	11.

(*b*) What degree of access do you have to military facilities, and what access do they have to NASA facilities?

Answer. The arrangements between NASA and DOD in the area of facilities use has generally been through some form of agreement. We have access to each other's facilities for programs that cannot effectively be conducted in the available facilities. Based on experience NASA feels its access to military facilities is reasonable. This is in light of our mutual understanding that the host-scheduled projects and facility capabilities must be considered and relative priority established for each project. These procedures generally entail some adjustments by both parties in order to maximize the total output of the facility.

(c) How do you determine what new facilities are required, and what method is used to assure that there is no duplication of effort?

Answer. The need for new large aeronautical facilities receives continuing attention by the Aeronautics and Astronautics Coordinating Board (AACB). This is a joint NASA/DOD board charged with coordinating NASA and DOD research activities including facilities. The AACB is co-chaired by the Deputy Administrator of NASA and the Director for Research and Engineering of the Department of Defense.

In a further effort to assure that any possible duplication of facilities is identified, NASA and DOD reviews each others construction of facilities programs each year. If it is considered that there is an unwarranted duplication of facilities this is pointed out. This procedure is fully documented and is initiated early in the budget formulation cycle each year. Since these procedures were initiated there has not been any unwarranted duplication of facilities.

(d) What wind tunnel projects are currently under consideration by either NASA or the military, and what is the current status of any such proposals?

Answer. NASA does not know of any wind tunnel projects currently being considered by the military. However, NASA is considering two major wind tunnel projects, the construction of National Transonic Facility at the Langley Research Center, Hampton, Va. and Modification of 40- by 80-foot Subsonic Wind Tunnel at the Ames Research Center, Moffett Field, Calif.

Construction of National Transonic Facility, a high Reynolds number, fan-driven, closed circuit, wind tunnel is being proposed as a fiscal year 1977 project. Final design of the facility is underway and is about 30 percent complete at this time. Final design is scheduled for completion in mid-1977. The facility is scheduled to become operational in mid-1981 based on a 3 sequential year funding plan totaling about $65 million.

The 40 by 80 modification as now planned would be accomplished in two phases. The first or "repowering" phase is to be considered a top priority candidate project in fiscal year 1978. The second phase, the addition of a new test section leg would then be provided for in some future years' programs. The design for the repowering phase is about 75 percent complete at this time and will be finished in July 1976. Preliminary design of the "new leg" is completed. Further final design to complete the design for the "new leg" is planned for fiscal year 1978.

NASA also upgrades and rehabilitates existing tunnels as part of a continuous program to maintain and improve our basic test capabilities.

Mr. BOLAND. We will stand adjourned until 9 o'clock in the morning.

THURSDAY, FEBRUARY 19, 1976.

Mr. BOLAND. The committee will come to order.

UPPER ATMOSPHERIC RESEARCH

We will turn to page RD 4–29, "Upper atmospheric research." Your request for fiscal year 1977 is $11,600,000 for continuation of your work in assessing the ozone reduction. Have you learned anything to date about this, and do you have any idea what the impact of the Concorde will be on the ozone layer?

Dr. FLETCHER. Mr. Chairman, we have done a great deal of work to date, and Dr. Hinners will report on the status. We do have a fairly good idea on what impact the supersonic transports have on the atmosphere. But of course, we have to define what we mean; if it is the Concorde aircraft, how many flights, and so forth. But Noel, I think you have the latest data on that. Would you respond?

Dr. HINNERS. Yes, sir.

On the general problem of the ozone, we have been focusing our efforts in the last year on the fluorocarbon question. We have had

several successful measurements now that prove that the fluorocarbons are in the stratosphere. The second point that has been now established is that the fluorocarbons are decomposing from the effect of the ultraviolet light, releasing the element chlorine, which then interacts with the ozone.

We made the first attempt to measure chlorine oxide (CEO) late last December. We were not able to detect chlorine oxide, but we did establish an upper limit; which says, of course, that there are no unknown sources of chlorine up there which would have an effect larger than that we predict from fluorocarbons. We have established new rate measurements for the hydroxyl interactions which enter into this process because they theoretically can take chlorine in and out of circulation.

We made our first measurement last year in the stratosphere, of the hydroxyl (OH). We made our second measurement in January of this year, which confirms what the theorists had predicted in terms of how much OH would be there. Everything we are seeing now lends credence to the theory. The measurements have done nothing so far to negate what has been predicted by the model and theoretical efforts. We feel we are on the right track, and are making the types of measurements which we need to confirm or deny these theories and hypotheses.

AEROSOL IMPACT ON OZONE LAYER

Mr. BOLAND. What about the problem of aerosol spray cans? What impact do they have on the ozone?

Dr. FLETCHER. The aerosols are the principal source of these chlorofluoromethanes. I do not know why we use these fancy words. Freon is a name for it. The principal source of chlorofluoromethanes—more than half—comes from aerosol cans.

Freon is used for other purposes; the other principal use is as a refrigerant. So we are referring to all uses of Freon when we say it does have these reactions that Dr. Hinners mentioned.

Dr. LOW. The actual effect, Mr. Chairman, in terms of how serious it is, is being studied. As Dr. Hinners mentioned, we are beginning to make progress in the measurements we can make, but we are a year away from having an assessment on how serious the depletion of ozone will be as a result of this effect. This is consistent with the commitments we have made, and other agencies have made, to provide for possible regulatory decisions in early 1978.

CONCORDE FLIGHTS

Dr. FLETCHER. You also mentioned the Concorde. To date, with the number of Concordes they are talking about, we could not measure any appreciable effect, because the number is so small. The flights across the Atlantic are even smaller, even if they are permitted. That would have a very minor effect on the stratosphere. If there were a large fleet of 500 Concordes or so, it might be noticeable. But right now, we can say with some assurance that the impact on the ozone layer of the small number of Concorde flights that are planned would be negligible.

Mr. BOLAND. I take it you would not agree with Administrator Train's position that the Concorde should have been banned on environmental grounds. You would not agree with him on the matter of sound, I am sure, because you are looking into that. You are not agreeing with him, apparently, on the basis of information at this point in time.

Dr. FLETCHER. It is my judgment that Mr. Train was primarily referring to the noise of the Concorde, and not the ozone layer. He was somewhat concerned about the extra noise.

Mr. BOLAND. Does anyone have any more information about aircraft noise than NASA or the FAA, really? No one does; absolutely no one does. You have measured noise on the planes that are now flying. I am sure that NASA has measured the sound impact of the various types of planes, and the size of the aircraft, and so forth, haven't you?

Dr. FLETCHER. Yes, Mr. Chairman, we have.

Mr. BOLAND. I know FAA has done it, too.

Let me ask NASA's judgment on the noise impact of the Concorde.

Dr. FLETCHER. We have written our opinion on this subject to the FAA, the Department of Transportation, which requested our comments. We felt that there was an essentially negligible noise impact for the number of flights that they were talking about. I think it was four flights at Kennedy and two at Dulles per day. We could not find any noticeable noise impact for that number of flights, and so we recommended going ahead on an experimental basis, and actually watching what happened, to assess people's feelings about the noise and to measure the operational problems which we think would be very important for any future transport of this sort.

VIKING PROJECT

Mr. BOLAND. On page RD 5–5, under "Lunar and planetary exploration," the budget justifications identify the funding for the Viking project. Both Vikings were launched successfully last year.

However, there has recently been reported in the press two instrument failures of the six instruments available on both spacecraft. Do these failures involve the basic mission of Viking, which is to determine whether life exists on Mars?

Dr. FLETCHER. No, Mr. Chairman. These failures involve only what we call the GCMS. That is a fancy term for gas chromatograph mass spectrometer, which is one instrument that determines the chemistry on the planet Mars. Actually, we will still obtain data on the chemistry of the planet. It is just that we will not get as much data as we had originally anticipated, because of these failures.

Dr. LOW. If those instruments actually failed and that is not completely clear, we will not know this until the landing on Mars. The worst that would have happened is that we would, if each landed, be able to sample the chemistry of only two samples each instead of three. Nevertheless, we will still get samples, and most of the samples we are looking for. There are many other instruments on the Viking that are functioning perfectly.

Dr. FLETCHER. It does not affect the biology instruments at all. They are not connected to this possible problem.

Mr. BOLAND. Are any other problems showing up that have not been reported with respect to this mission?

Dr. FLETCHER. No, Mr. Chairman. No other problems have shown up so far.

Mr. ROUSH. Are you still going to land on the Fourth of July?

Dr. FLETCHER. We are still discussing that target landing with the scientists. I think there is a very good chance that we will. There are some symbolic reasons why we should. The only possible cause for delay is that we want to be sure to survey the landing sites very carefully before the landing, because the location does make a difference. But we have, I think, enough time so that the chances are good that we will land on July 4, 1976.

Dr. LOW. The first Viking will arrive in orbit around Mars, I believe, on June 19. Then, it is a matter of deciding how many days of search we need to clearly define the best landing site.

Mr. ROUSH. How high will the spacecraft be in orbit? What will its apogee and perigee be?

Dr. HINNERS. I would have to get the exact numbers. The low point is about 1,000 miles.

Mr. ROUSH. At that distance, can you determine whether you are going to land on a rock or not?

Dr. FLETCHER. Not on a rock. But we can look at the terrain and see whether it seems smooth, or whether it seems mountainous, or whether it is on an incline. The gross features we can tell.

PIONEER VENUS PROJECT

Mr. BOLAND. Turn to page RD 5–10, Pioneer-Venus. The justifications describe the Pioneer-Venus project. These missions are designed to investigate the atmosphere of Venus, and perform scientific investigations of other aspects of the Venusian environment. As you know, this subcommittee suggested that the program be delayed until the next available Venus encounter, and flown on the Space Shuttle. This mission includes two spacecraft, an orbiter, and a multiprobe vehicle. The stated primary objective of the twin missions is to study Venus and its environment. The scientific community contends that a detailed investigation of Venus' atmosphere and clouds would be conducted, which could lead to information leading to a better understanding of our own atmosphere.

After our subcommittee acted last year, the Soviet Union launched the two Venus satellites, Venera 9 and 10. Each Russian satellite also consisted of an orbiter and an entry probe. Is it not fairly safe to assume that the Russian scientists would also be looking at some of the same questions posed for our Pioneer-Venus mission, and would they not have scientific instruments aboard similar to those on Pioneer-Venus?

The United States recently signed a treaty with the Russians designed to cooperate in space. It would seem that this might be an excellent opportunity and a good example to determine what the treaty involves, and whether or not we are getting the cooperation that the treaty envisions. And it would appear that there may be some unnecessary duplication here.

What about this?

Dr. FLETCHER. Mr. Chairman, your point is very well taken. We have a fairly well understood cooperative program, in the sense that the Russians are making a thorough exploration of the surface of the planet, and in landing on the surface they did find some rather startling things about the nature of the rocks on the surface, and some surprises about what the winds aloft might be like. Our focus is complementary to theirs, in the sense that we are looking at the atmosphere.

Now, to us, the atmosphere seems more important, because surprisingly enough, some of the many dynamic processes occurring in our own planet's atmosphere, we first discovered from scientific investigations of Venus. All this concern about the ozone and the stratosphere, for, example, on our planet was first hinted at by scientific discoveries about the Venus atmosphere.

I think we are having a pretty good exchange of data about Venus between the two countries. They do give us the surface data which they obtained from their landing, and we plan to give them our atmospheric data. There is a good exchange.

Our Pioneer-Venus instruments are quite different and will measure the atmospheric characteristics, rather than the surface characteristics.

SPACE APPLICATIONS

Mr. BOLAND. On page RD 7–1, the justifications display the funding for the Office of Space Applications, and the table reflects the funding for the space applications program. It shows an increase of $20 million over the current level of 1976. And it also reflects continued peak-year funding for Landsat–C and Seasat.

In the February 5 issue of Space Daily, there is a headline: "NASA Applications Program: Lip Service." Quoting from a report "With all the concern being expressed in Congress about the need for utilizing the potential of space for men on Earth, one would think the NASA space applications budget would be getting a boost. This is not the case."

POSSIBLE APPLICATIONS ACTIVITIES WITH ADDITIONAL FUNDS

It goes on to point out that Mr. Mathews emphasizes the application of space capabilities to practical uses has proceeded at a very modest budget level. I wonder if you could provide for the committee—and this could be done for the record—what specific programs or missions you would fund if you had an additional $20 million available in this area in fiscal year 1977.

Dr. FLETCHER. We will be glad to do that, Mr. Chairman. There are many good programs in that area which we would like to fund if we had the money.

[The information follows:]

If additional funds were made available on a sustained basis, they would be used to accelerate and expand the development effort on materials processing experiments in space, and on the Atmospheric Cloud Physics Laboratory along with a more optimum development schedule for the Thematic Mapper. In addition, the effort in the Earth Dynamics Program would be increased in the area of modeling, technology development, studies and user cooperation. The research and technology would be augmented in satellite communications and data systems.

Our transfer activities would be increased in scope. This would accelerate the process of having the users become familiar with the earth resources capabilities

and provide for the training of larger numbers of people to support those resulting uses. We would support expanded work directed toward the next generation earth resources systems. New initiatives which we would consider include development of satellite based search and rescue and disaster warning systems.

Additional funds would be invested to expand our basic research in the areas of meteorology and climate phenomena. Another area of research that would be expanded would be that of pollution detection and monitoring, particularly with regard to air pollution and its effects on climate.

Mr. ROUSH. Mr. Chairman?

Mr. BOLAND. Mr. Roush.

POTENTIAL NEW SOURCES OF ENERGY

Mr. ROUSH. Dr. Fletcher, is there any source of energy available to us—and more particularly, research for which might be within your jurisdiction—which is not being explored?

Dr. FLETCHER. Mr. Roush, your question is a good one in this sense. There are many programs that should be explored. As you know, there are no funds in NASA's fiscal year 1977 budget for direct terrestrial energy R. & D.—Energy Technology Applications.

SOLAR ENERGY

However, let me give you an example. We feel at NASA very strongly that, ultimately, the whole Earth is going to use solar energy as the basic source of energy for our whole civilization. Because all these other sources are going to run out. But there is a sizable investment in solar energy in this country, and much of the technology resides at NASA. We have a solar heating and cooling program. We have a small program in producing electricity from the Sun. We think that program could be greatly augmented, and we could begin to utilize solar energy much earlier by a larger investment made now.

But, of course, with the budget constraints, we could just not put enough money into that whole program.

Mr. ROUSH. I did not really believe that either the administration or the Congress would feel contrained to hold back in appropriations for that type of research, if there was any chance, any chance at all, that it might be productive. Maybe I am wrong in my assmption. Certainly, the action that is taken by the Congress, as we discuss the authorization bill, would indicate that Congress wants to discover new sources of energy.

The Congress is cognizant of the fact that the resources on this globe of ours are finite, and we are anxious to do this. And that is what prompted my question.

Dr. FLETCHER. Of course, energy is not primarily NASA's responsibility. But we can comment on solar energy, because that is what we use for most of our satellites. We know about solar energy, and we use it extensively. I think Congress has not been reticent about putting funds into this program. But there has been a little relutance to put too much in solar energy, because of the large investment we have already in this country in nuclear energy.

Mr. ROUSH. Actually, do we not have just a minimum program going insofar as research is concerned in capturing solar energy outside this atmosphere, and transferring it to this Earth?

Dr. FLETCHER. Quite frankly, Mr. Roush, I think it is subminimum.

We need to have discussions with ERDA to see if they cannot reprogram some of their funds into that program. But as you know, our line item for that was eliminated for fiscal year 1977 and we were asked to go to ERDA for those funds.

Mr. ROUSH. Do you know how much ERDA has devoted to this?

Dr. LOW. ERDA has, in its fiscal year 1977 budget, I believe on the order of $80 million for solar electric research.

Mr. ROUSH. Now, you say solar electric research. Is that earthbound research as well as space research?

Dr. FLECHER. Mostly earthbound.

Dr. LOW. When the budget was put together, it was all earthbound. When the decision was made by the administration that there would be no NASA funding for efforts such as satellite solar power, we hoped that ERDA would reprogram some of that money to fund NASA efforts.

Mr. ROUSH. What amount could NASA usefully use in research, in solar research in space?

Dr. FLETCHER. That is a tough question to answer.

Mr. ROUSH. I know it is.

Dr. FLETCHER. Let me answer another way which might be helpful. We had $8½ million in our fiscal year 1977 request to the President for energy research and development. This was partly for studying concepts of collecting energy from the Sun, and also partly for seed money to look at new sources of energy. That NASA funding was eliminated, and we were asked to see if we could try to get that money from ERDA. So it is at least $8½ mililon. That is about all I can say.

Mr. ROUSH. I would imagine that that is a minimum amount. Maybe it is like you said, even then, subminimum.

Dr. FLETCHER. It is difficult to say how much the total could be, because there are many possibilities.

ENERGY FUNDING

Mr. ROUSH. With reference to the decision to eliminate direct NASA R. & D. funding for direct energy applications, what are your personal views as to the feasibility of NASA depending upon ERDA for funding these activities?

Dr. FLETCHER. I feel that solar energy is particularly grossly underfunded. I think that we ought to start now a large program to harness solar energy comparable to what we started 20 years ago in nuclear energy.

We are in a tough budget year, let's face it, with a large deficit, and the overall Government outlays are being cut back $28 billion. It's hard to start a major new thrust in a form of energy of this sort in that kind of an economic environment. And so I don't feel now is the time to press for a major thrust forward in solar energy, but ultimately I feel certain, personally, that that has to be done.

Mr. ROUSH. Now, let's see, Dr. Fletcher, was that responsive to the question?

What are your personal views as to the feasibility of NASA depending upon ERDA for funding of these activities?

Dr. FLETCHER. Since we have just started negotiations with ERDA, it is really too early to say. We are going to try our best to get most of this money that we originally requested for this budget from ERDA.

Mr. ROUSH. Was the ERDA budget adjusted so as to accommodate requests for $8½ million?

Dr. FLETCHER. No, it was not. ERDA tells us it was not.

ERDA PLANNING

Mr. BOLAND. I suppose this situation is not necessarily bad in that ERDA would supply the funds to NASA for this research, provided NASA could look to a continuation of adequate funding to do its job. That is about the size of it, isn't it?

You know, under the authorization bill, ERDA is establishing a solar energy research institute that apparently envisages, I presume, a great deal of research in solar energy. That institute is supposed to be set up sometime this year, and I presume most of the research for solar energy will be directed to that institute. Can you comment on the mission of the institute?

IMPORTANCE OF ENERGY TECHNOLOGY

Dr. FLETCHER. It is my understanding the institute will focus primarily on research, that is to say basic research for long-range programs.

What I was referring to is technology, which is one step beyond research. I think that there are a lot of possibilities that we know about now that we could really start exploring, if we had the funds.

By the way, not just solar; geothermal is another place we could look very hard at. We know there is energy there, but we have to develop the technology to extract it economically.

There is also energy in the oceans, and that is really just a form of solar energy because it is temperature differences or temperature gradients in the ocean that allow you to make heat pumps to extract the energy.

All of these sources are potential places for finding enegry, and the research institute is going to do energy-type research, as I understand it, and not develop the actual techniques to produce it economically.

ENERGY REQUIREMENTS

Mr. BOLAND. Considering the energy requirements for this Nation today and in the distant future, are we really going to meet those requirements by sources other than fossil fuels and nuclear power?

Dr. FLETCHER. It depends on how far into the future you look.

If you look in the next 20 or 30 years, fossil fuels and nuclear fission are probably good ways to go, except they have environmental problems, as you know.

In the long range, 100 years, you know that solar energy is probably the likely place we will get energy.

Mr. BOLAND. We are not going to be around 100 years from now.

Dr. FLETCHER. I know. But still, we have to worry about our grandchildren. In the short term, it is our current view that solar energy can be made to be competitive with nuclear and fossil fuels, and it doesn't really have much in the way of environmental impact. I think you've got to look at that possibility, as well as the other two, to make sure you are tapping the best sources of energy available.

SOLAR ENERGY-ECONOMICS

Mr. BOLAND. But in our time is solar energy going to be competitive with nuclear or fossil fuel?

Dr. LOW. Mr. Chairman, we have made some preliminary studies in NASA of one form of solar energy; namely, solar energy collected in space and then beamed to the Earth via microwaves. Based on these early studies it looks as though it could well be competitive. By the time such solar space stations could be placed into space, which is on the order of 20 years from now, they could handle all of the added capacity over and above the then current level of electrical power consumption. So it not only would be a competitive situation, but it could also be one which takes a dramatic part of the total energy consumption away from other sources of power.

SOLAR POWER SATELLITE CONCEPT

Mr. BOLAND. How does this system work? You say it is a beam transmitted to the Earth? Can you describe the system?

Dr. LOW. You would put into a high Earth orbit, a so-called stationary orbit, a large array of solar cells or solar collectors. These would be the kind of solar cells that we have on our spacecraft now to make electrical energy for spacecraft, except they would be much larger. We would measure the size of that area in terms of square miles, 3 or 4, maybe up to 20 square miles.

That electrical energy would then be converted to radio waves or radar waves, and these radar waves would be beamed to the Earth as a small concentrated beam and would be collected on the surface of the Earth by an antenna.

That antenna would not have to be located in an area where the Sun shines; it could be located anywhere, because those waves will go through clouds. It would not have the limitations of collecting solar energy on the Earth.

In the antenna these radio waves would be converted to electrical energy, which would feed a city, for example, just as a power station does today.

Mr. ROUSH. Do you envisage that that power station would be competitive with an earthbound solar power station?

Dr. FLETCHER. Yes, Mr. Roush, we do envisage that; but we want to be sure of it and we are making a study to be sure we made a good economic comparison between the two.

It is a little hard to understand, at first, because, it would normally appear that it ought to be cheaper to do it on the ground than in space; but you have to remember that on the ground sometimes the weather is bad, and you don't get any solar energy. Also, half the time it is night, and the collection is not getting any Sun, so you have got to have enormous storage facilities.

Another factor is that the Sun is attenuated coming through the atmosphere by a factor of 2 or 3.

So if you put all that together, a space-based solar power satellite system concept seems promising.

In fact, there is one proposal that says, if you really want to do it on a mass scale, you could even assemble new space stations out in space instead of assembling them on the ground. That is a little far out.

Mr. ROUSH. It's not any further out than colonizing some station.

Dr. FLETCHER. No; it is basically that; they would colonize the station and build new commercial stations to beam at the Earth.

I would not want to propose that now. I am only indicating that it might very well be competitive even though it seems surprising at first.

PUBLIC SUPPORT FOR SPACE PROGRAMS

Mr. ROUSH. I'm somewhat disturbed. Dr. von Braun told us this story—how long ago, 4 or 5 years ago—when he was before the committee, he related exactly what Dr. Low has told us today.

As I recall his example, he said that an array on the Earth of something like 2 square miles could—with the proper station—provide the power for a city the size of Metropolitan Washington, D.C., and that has been 4 or 5 years ago. Yet we apparently still have done nothing.

Yesterday we talked about the fact that we have lost the imagination of the general public, and it just seems to me that this is the type of thing that could recapture the imagination of the public and cause a resurgence of confidence in the type research that NASA has been authorized to do, and which the law contemplates that it would do, and something like this could happen.

I can see us not only recapturing the imagination of the people, but strong, strong public support for the expenditure of funds to meet what is going to be a desperate need in just a few years for the people of this Earth.

Mr. BOLAND. Wouldn't the people of the Earth get a lot more out of that than a large Space Telescope, for instance?

Mr. ROUSH. Yes; I suppose they would. I don't know if we are comparing the right things here, but, nonetheless, they would, and that expenditure is one they would appreciate and support, I would think.

Dr. FLETCHER. I think I completely agree with what you said, Mr. Roush, and I think we have been a little slow in making economic analyses.

On the other hand, we do think that before we propose large expenditures in this area, we do need to be on sound economic grounds. We are getting there; we think we are getting very close to being competitive economically.

SOLAR POWER SYSTEM FUNDING

Mr. ROUSH. Dr. Fletcher, what do you need to make an economic analysis, as you described it? Do you need money to make it?

Dr .FLETCHER. Yes, we need money.

Mr. ROUSH. How much money?

Dr. FLETCHER. We would need to have about $5 million in fiscal 1977 and more in subsequent years.

Mr. ROUSH. If you had $5 million in fiscal year 1977, how long would it take you to make that economic analysis?

Dr. FLETCHER. That is a good question. I have not thought too much about the length of time required.

Dr. LOW. We have a plan developed by a team that we have put together in NASA to look at this concept. That plan says that in a period

of 3 to 5 years we should be able to have the technology in hand, and the analyses to go with it, to say whether this concept is indeed worth pursuing.

Mr. Roush, it is not only the paper analysis, but one of the factors, one of the very important factors this concept, is to drastically reduce the cost of solar cells, reduce them by a factor of 40 or 50.

Now, on paper, we think we know how this could be done; but before one can commit to such a concept, one has to really build solar cells, develop and test them, and find out whether they can be produced for a factor of 40 or 50 less than they cost today.

In addition to doing the economic analyses, one also has to do technological development; and our satellite solar power team came up with a program that would be considerably more than $5 million, something on the order of $150 million to $300 million over 5 years to put the country in a position to say whether we should start spending the billions that it will take to put power into space.

So it is more than just a 1-year effort. But in the first year, $5 million would give us a good start on that.

Mr. ROUSH. You may want to elaborate for the record on this.

I am not sure I speak for the subcommittee, but I think it is a matter in which the subcommittee has a deep, deep interest.

Mr. BOLAND. I think one of the problems that Congress faces is that, you know, in the name of energy, there can be an awful lot of wastage of money; an awful lot of sins can be committed in the name of energy. I think that is one of the problems we have to guard against.

LANDSAT–C/GAO STAFF STUDY

Mr. ROUSH. On page RD 7–9, the justifications outline the funding for Landsat–C. This program has come in for review by GAO. Looking at costs, NASA indicated that their total planning estimate for this project was $35.7 million. The GAO contends that the cost of the multispectral scanner was not included in that estimate.

Should it not be?

Dr. Low. Mr. Roush, that is a matter of the history and timing in terms of the estimate. We don't disagree with the GAO that the total cost of the Landsat–C should include the cost of the multispectral scanner. It is in there now. But we did not hide it from the committee last year. It was discussed with the committee and with all the committees as a separate line item. The line items have been combined in the fiscal year 1977 budget.

Mr. MATHEWS. Let me explain that. When we were in the process of requesting approval to proceed with Landsat–C, the multispectral scanner was already in the NASA budget as a separate line item. It was always made evident that the multispectral scanner would go on Landsat–C.

As soon as the money was appropriated and apportioned for the Landsat–C project, our operating plan integrated the multispectral

scanner into Landsat–C. In the fiscal year 1977 budget they are now integrated and the current point estimate for the total Landsat–C project is $42.7 million. That excludes the launch vehicle cost of $5.2 million.

Mr. ROUSH. Since last year's hearing, NASA/Goddard has estimated cost increases of $4.5 million. Do you agree with that estimate?

Dr. FLETCHER. Chuck Mathews has the answer to that, too.

Mr. MATHEWS. No, that is not correct. At the time of the GAO investigation, the Goddard people came to us and indicated that there were some questions about the costs on the project.

Subsequently, we negotiated those costs, and they have not changed. The cost of the multispectral scanner, $7 million, added to the $35.7 million Landsat–C cost estimate adds to $42.7 million.

Goddard and we agree that those are the correct cost estimates.

There may be a slight difference in the split between those two, in that the multispectral scanner is currently underrunning by one-half million dollars, and the Landsat-C costs have increased by one-half million dollars. In addition, we have somewhat reduced our APA, but this is logical at this stage of the project.

Dr. FLETCHER. APA is allowance for program adjustment.

Mr. MATHEWS. It has gone from $3 million down to $2.4 million, but we are already 1 year into the program, and have only 1½ years to go. This is the way we use APA in a project. It decreases the closer that you get to the end of a project. We do not agree with the GAO position. Of course, they were aware of that particular fact during the investigation.

Mr. ROUSH. I guess what you are telling us is that you do not agree with the estimate, because they rather specifically point out here that there is a projected cost increase of $4.5 million, on page 11 of their report.

Dr. LOW. Mr. Roush, I think it is a question of the timing of when the GAO made its investigation, and where we stand today. At the time that the analysis was made by the GAO staff—I realize that their report is dated January 30, but this report goes back to GAO work done earlier—Goddard people, as Mr. Mathews pointed out, had said that they thought Landsat-C would cost more.

It is a function of Mr. Mathew's operation in Headquarters to keep costs down. He worked with Goddard and the contractors and was able to hold the line on the cost. Mr. Mathews is still committing to the $42.7 million total cost estimate, as he previously had.

Mr. ROUSH. What led Goddard to the conclusion that is set forth here in the GAO report?

Mr. MATHEWS. Let me go into that. I can supply a comparison of numbers between the GAO numbers and the Goddard numbers.

Mr. ROUSH. If you can, I think that will be instructive.

[The information follows:]

The Headquarters' estimate for the LANDSAT–C Program as reconciled against the table shown on page 11 of the GAO LANDSAT Report is as discussed below:

[In millions of dollars]

	NASA [1] March 1975 planning estimate	GSFC [1] project Ofc, October 1975 estimate	Current NASA headquarters estimate
Spacecraft	19.15	21.90	21.90
Payload	6.75	7.95	[2] 6.80
Ground operations	6.20	6.90	[2] 4.70
APA	3.00	3.00	[2] 2.40
IMS	.60	.45	[3] .40
Subtotal	35.70	40.20	36.20
Multispectral scanner	7.00	7.00	[4] 6.50
Total	42.70	47.20	42.70

[1] From GAO Study titled, "Land Satellite Project," dated Jan. 30, 1976.
[2] These are target reductions within the LANDSAT-C runout estimate of $42,700,000. Headquarters and GSFC are agreed that these constitute valid planning targets. Detailed resolutions among items within the total $42,700,000, will be made over the next several months.
[3] GSFC reevaluated their charges to the program and concluded that they had been overstated and subsequently agreed they should be reduced.
[4] Current evaluation of multispectral scanner (MSS) runout cost estimate indicates an underrun of $500,000. These funds will be used (as shown by the estimate) to offset added costs in the rest of the LANDSAT-C program.

Mr. MATHEWS. In the spacecraft, there has been an increase. This is the result, primarily, of inflation effects. We do agree with the number for the spacecraft that was in the GAO report of $21.9 million.

All the in-house Goddard support—they have small contracts where they are supporting various aspects of the LANDSAT-C project—were included in that number. The Goddard estimate, in addition to including the full amount in that number, had also included in the payload a prorated share of the in-house support.

This occurred because there were two independent groups at Goddard that made those estimates. In one case, the group aggregated both the numbers. In another case, the group included their own.

We did not agree with the payload increase. The payload number stays the same as we had it originally and does not increase.

Now, in addition, Goddard proposed as a part of LANDSAT-C to augment the ground facilities, which I have not agreed is a part of the LANDSAT-C program. We can do without it, or we can raise the issue as a separate item in another budgetary year if we want to include those, but they are not part of the LANDSAT-C program.

These are the types of things that we have negotiated with the Goddard people. As Dr. Low says, it is a matter of headquarters doing its job of making sure the estimate is correct. I think one has to be fairly careful when going to a center, to really understand the context in which the Center is providing the numbers.

As a result of our subsequent negotiations, Goddard and we agree completely on what the numbers should be.

Mr. ROUSH. It has been pointed out that a major goal of the LANDSAT project is to gain sufficient experience to decide whether there should be an operational earth resources satellite system. The GAO feels that NASA should take the lead in developing a comprehensive, long-range plan directed at this goal. Are you doing anything along these lines, or should anything be done?

Dr. FLETCHER. We agree with that recommendation. I think we have actually started some effort in this direction. But, of course, this cannot be done by NASA alone. We can take the lead, as the GAO suggests, but we do have to work with the various users.

NOAA is represented on a planning group, along with the Departments of Interior and Agriculture. We have this group trying to put together what we think is a reasonable operating plan.

It has just barely started, Mr. Chairman, so we cannot say precisely when it will be finished. But we do agree with that recommendation.

Mr. ROUSH. Do I gather from your answer that you are doing just a little bit more than some thinking?

Dr. FLETCHER. We have established a group to formulate a first draft, at least, of that kind of a plan.

Mr. ROUSH. I guess we are all aware of GAO's relationship to the Congress. It is an arm of the Congress, and they are supposed to be right when they make an analysis of a program or, in response to a request from Congress, make an investigation. And the last couple of days, they have not been right once, have they, on the questions that we have raised here?

Dr. FLETCHER. In the case of LANDSAT, I think they had a point, but they had old information. I think it is not fair to be too critical of GAO on that particular report. As Mr. Mathews mentioned, there were differences when they first looked at it between Goddard and Headquarters, and there was a duplication problem which we had to clarify since the report was written.

Mr. MATHEWS. I might mention, Mr. Chairman, that, really, we think the GAO report on LANDSAT is quite a good report, and we certainly agree, as Dr. Fletcher said, about the planning consideration.

THEMATIC MAPPER

Mr. ROUSH. On page RD 7–10, the justifications indicate a new start known as the Thematic Mapper?

Dr. FLETCHER. Yes.

NEED FOR THEMATIC MAPPER

Mr. ROUSH. You are requesting $4 million for this program in fiscal year 1977.

Why is this needed, and how is it different from the LANDSAT–C?

Dr. FLETCHER. The Thematic Mapper is an instrument which someday will probably go on an Earth resources satellite. It is an improvement in capability over the multispectial sanner in the current LANDSAT–C.

It will be an improvement in two ways. It will have higher resolution; that is, it will have the capability to see smaller objects on the ground. It also will have extra channels, so that instead of having only five bands, the Thematic Mapper instrument will go up to six or seven bands.

Basically, it is a more advanced instrument that will be used in a satellite like LANDSAT–C someday.

Mr. ROUSH. But it is needed?

Dr. FLETCHER. Very much so.

SEASAT COST ESTIMATE

Mr. ROUSH. On page RD 7–21, the justifications describe the ocean dynamics satellite, better known at SEASAT. The fiscal year 1977

request is $25,300,000. When that is added to the $5 million provided for the transition quarter, the $15 million provided in fiscal year 1976, and the $8 million provided in fiscal year 1975, the total to date, including the fiscal year 1977 request, is $53,300,000.

Last year—and I am referring to page 466 of the hearings—you estimated that the SEASAT cost estimate was between $50 and $60 million.

What will be required to complete the funding of this satellite in fiscal year 1978? And does that complete the funding of the program?

Mr. MATHEWS. Mr. Chairman, the SEASAT–A project cost estimate, excluding the launch vehicle, is $65 to $75 million.

Mr. ROUSH. Would you repeat that?

Mr. MATHEWS. $65 to $75 million, excluding the launch vehicle, Mr. Chairman.

Mr. ROUSH. Why the increase, then?

Mr. MATHEWS. Mr. Chairman, the configuration of the satellite has changed as a result of a very strong input from the scientific community. Initially, the capability for measuring sea surface temperature was not included on that satellite. We did receive very strong indications from the various elements of the user community, particularly the meteorological community, that sea surface temperatures should be measured on that satellite.

So we then went through a review involving the scientific community, along with the user community, and brought the problem to Dr. Fletcher. He agreed that this capability should be incorporated.

We then discussed it with the OMB. They agreed that it should be incorporated. So the capability of the satellite has been increased in that respect.

Mr. ROUSH. Now, was the same information provided to Congress, the change or the addition that you made?

Mr. MATHEWS. I think Congress was informed, but I am not positive of that.

Mr. LILLY. There are two separate reports that are provided twice a year on changes to total project cost estimates. One is to the authorization committee. The other is to Senator Proxmire's subcommittee. Both of those projects were included in those status reports and the reasons were given for the increases.

Mr. ROUSH. Now, does the total funding estimate that you have made satisfy GAO's belief that all costs associated with a project should be identified and reported to Congress?

Mr. MATHEWS. We have also reported to the Congress that there is additional support needed for the SEASAT project, in terms of flying some of the instruments in our airplane program. So that is a cost that we have identified to the GAO as an effort that is over and above the project cost.

This is the normal way we handle an airplane program effort. It is not included in the individual project cost, such as LANDSAT, SEASAT, or one of the meteorological programs. It is carried as a separate line item.

Mr. ROUSH. If there is no increase in NASA's fiscal year 1977 and future budgets, what existing projects would be cut to fund the increase of $16½ million in SEASAT–A project costs?

Mr. MATHEWS. In terms of the fiscal year 1976 amount, Mr. Chairman, we did reduce the advanced research and technology program in the area of Earth dynamics, to accommodate this activity.

However, in the fiscal year 1977 budget, the increment is a part of our budget request.

TIROS–N SCHEDULE AND COST ESTIMATE

Mr. ROUSH. Is the TIROS–N weather satellite described on page RD 7-32 on schedule and targeted for launch in 1978?

Mr. MATHEWS. Yes, Mr. Chairman, it is on schedule, and it targeted for launch in January 1978.

Mr. ROUSH. Is the mission being carried out within the original cost estimates?

Mr. MATHEWS. Yes, it is. The TIROS–N project's current point estimate is $42 million. That is within the original estimate.

Dr. FLETCHER. The range has remained $40 million to $50 million, Mr. Chairman. We cannot be completely precise this early, but it is still within the $40 million to $50 million that we have been estimating for the TIROS–N project.

AERONAUTICAL RESEARCH AND TECHNOLOGY

Mr. ROUSH. On page RD 8–1, the justifications outline the funding request for aeronautical research and technology in fiscal year 1977. An increase of $13,750,000 is requested.

I have some general questions.

IMPORTANCE OF TECHNOLOGY TO MAINTAIN U.S. LEADERSHIP IN AERONAUTICS

Recently, some people have been beginning to draw an analogy between the American passenger railroad system and the American passenger air carrier system. They point out that when the railroad could no longer afford to purchase modern equipment, they gradually became less competitive. And I don't believe it is any secret that the airlines in this country are finding it harder and harder to make a profit, particularly since their fuel costs have gone up as they have. With less profits, the outlook for new developments from airplane manufacturers could be very gloomy.

Is that a problem; and if it is, how do you view it, from NASA's point of view?

Dr. FLETCHER. As Dr. Low mentioned yesterday, it is a problem, and we think new technology does need to be developed so that we can be competitive.

We did have the advantage in earlier years resulting from a transfer from military aircraft developments, but that is being lost.

I think the aviation industry is almost unanimous in saying that we need to develop technology for future new aircraft.

George Low has gone into this in more depth and may want to comment further. It is a real problem.

Dr. LOW. I think that Dr. Fletcher has covered it. It is pretty clear, first of all, that worldwide there will be a major market for new air-

planes over the next 10 or 15 years; and as soon as somebody develops the technology that allows an airplane to be operated for 25 or 30 percent less cost than today's operating costs, all competing airlines will have to start placing orders for that airplane, because, otherwise, they could not stay in business.

Now, how an airline stays in business and how the aviation industry stays in business is an extremely complicated subject that involves financing the investment of capital, the operating cost, the return on investment.

But I think it is pretty well understood in the whole business that as operating costs are driven down, airlines do find a way to reequip themselves.

The U.S. companies have, over the last several years, been in a very poor situation because of the general economic downturn. But once the economy accelerates again, I think that the aviation business will also accelerate. Therefore, it becomes terribly important to have the right technology in the hands of our own aviation manufacturers. Otherwise, the United States will lose its competitive leadership in aeronautics.

RAILROAD INDUSTRY

Mr. ROUSH. Would that same philosophy hold for the railroad industry?

Dr. FLETCHER. It might have; but we would be speculating.

I think one point, Mr. Chairman, that we have to keep in mind is that railroads were right for this country as far as passenger traffic was concerned in the last century. The whole country developed as a result of the investment in railroads.

But now it is natural for this large country to turn to air travel. It is not necessarily true in smaller countries, such as Japan, and nations in Europe. However, for this country, air travel for passengers is the right way, and we do have to keep modern in order to integrate all parts of this vast country.

Mr. ROUSH. I have the feeling that rail traffic is becoming once again the right thing for us, because of the need to move large numbers of people.

Dr. FLETCHER. In certain sections of the country, that is true; but East to West, probably not so true.

Mr. ROUSH. I have been telling people that we can look to the future and see the day when the old interurban between Huntington, Ind., and Fort Wayne, Ind., a distance of 25 miles, will come back. Maybe I am all wrong on that.

Dr. FLETCHER. I don't want to contradict that. But I do think that for long-distance travel most people have shifted to airplanes—even the Chicago-to-Washington run.

Mr. ROUSH. Of course, the eastern seaboard is highly populated. That seems to me to indicate there is a desperate need to do something with rail traffic there; but that is part of my own philosophy.

CONCORDE SUPERSONIC TRANSPORT

I am going to ask the next question of Dr. Lovelace, by request.

In your opinion, is the Concorde here to stay?

Should the United States be developing an SST?

Dr. LOVELACE. If you mean, is the Concorde here to stay in the international scene, I think it is Mr. Chairman. You are current, I am sure, on the situation regarding its landing in the United States.

I think the question of whether the United States should develop a supersonic transport is a matter of when we can provide the technology to make an assessment of its economic viability.

Mr. ROUSH. Isn't someone else doing that for us?

Dr. LOVELACE. I would say we are behind in that regard. The French and British clearly now have the flying test bed that we do not have.

We have maintained a modest effort in supersonic cruise aircraft research and technology over the last 3 years since the decision in the United States to cancel the Boeing supersonic transport.

In my personal view, it probably was a mistake to reduce our level of technology expenditure to such a low level. We should be in a position today to have the hard technology to tell even the British and the French how to correct whatever technical deficiencies there may be in the Concorde that causes us concern about its operation in the United States.

Mr. ROUSH. Have the British and French done enough yet to determine whether or not their SST, the Concorde, is going to be economical? Is it going to be cost effective?

Dr. LOVELACE. I think it is marginally so; and in my view, if it does not get the North Atlantic runs for which it was designed, it will probably be an economic failure.

Mr. ROUSH. If you were the owner of an airline here, you probably would not spend $50 to $60 million for an SST plane?

Dr. LOVELACE. I think that's probably true, if I were operating one of the U.S.-flag carriers. However, for the future, that might not be the case, if there is a followon development to the Concorde, either a U.S. development or a Western European development.

NASA SUPERSONIC CRUISE AIRCRAFT RESEARCH

Dr. LOW. Mr. Roush, if I might interject here, we are working on supersonic cruise aircraft research and technology in NASA, and we are beginning to see the light on technologies that could produce for the future, for the United States, an environmentally clean and economically successful supersonic transport.

When and how the United States should go into the business of having such a transport is a matter for the future to decide. It will depend on many, many factors that are beyond NASA's reach.

As people who are charged with developing the technologies for future aircraft, we think that when the time comes for such a transport we will have the technology in hand for, as I said, a quiet, clean and economical SST.

U.S.S.R./BRITISH-FRENCH SST TECHNOLOGY

Mr. ROUSH. Is there much difference between the Soviet technology in this regard and the British-French technology?

Dr. FLETCHER. Not so that we could tell any difference. They have similar problems. They are not necessarily economical, as far as we can tell; either one of them. They are both noisy; and they have these other problems that were discussed.

ECONOMICS OF U.S.S.R. SST

Mr. ROUSH. Do you have any indications as to whether or not the Soviet plane is any more economical, or are they plannnig to use it in a way which would mean that it is more cost-effective?

Dr. FLETCHER. I will have to speak for myself; the others may have more information.

We don't have a good a way of judging Soviet economics. They do economics differently than we do over here; and I would defy almost anybody to calculate whether they can say it is economical or not.

But maybe somebody knows more than I do.

Dr. LOW. I think the important point, about both the Soviet TU–144 and the Concorde, is that those countries are flying in Europe, and they have the basic experience of building a first-generation supersonic airliner. It is going to take some effort for this country to really have the technology in hand, which does not only apply to a supersonic airliner, but also applies to the aircraft industry as a whole.

So by working those very difficult problems, they have lifted up the general level of "know-how" in their aircraft industry. That is what we ought to be concerned about.

BOEING SST

Mr. ROUSH. Wasn't the Boeing SST substantially different from theirs?

Dr. LOW. Yes. The Boeing SST that was canceled 3 or so years ago was a faster airplane, somewhat different technology; but it also was not the kind of airplane that one would build with the technology that we now have.

Mr. ROUSH. How could Pan Am, for example, afford to buy one of these planes?

How can they compete if they don't buy it, perhaps I should say; say, with handling first-class passengers?

Dr. LOW. From what I have read on the subject, they will not compete on first-class passengers; but it is quite possible that they will get a larger share of the coach passengers, because it is likely that the Europeans will drop some of their existing flights on order to make room for the Concorde. Therefore, they will capture the first-class traffic, but at the same time lose some of the coach traffic, perhaps, to Pan Am and others.

So I don't think that the economic effect of the Concorde flying will be catastrophic at all on our own airlines.

Again, the concern is more about the future than what is happening this year.

Mr. ROUSH. Speaking personally, it seems to me the world is going pretty fast. I used to have a goal of reading 25 nonfiction books a year, and I would read them on the airplane between Washington and Fort Wayne, Ind., when it took 3½ hours. But I can't do that anymore. It takes an hour and a half of flight time, and by the time they serve a snack, which is nothing to brag about, and a Coke, there is just no time to read. And I just wonder if sometime we are not going to reach the place where there will be some resistance to us trying to do things in such a hurry, and it is really interfering with

human life, the values that we all appreciate, and some of the things we seek to enjoy. But that is neither here nor there, I guess, in this technical hearing that we are going through right now.

If we had not canceled our SST program, and we had gone ahead and built an SST back a few years ago, we would be stuck again; wouldn't we?

The technology would have outdistanced us, and we would have been behind.

SUPERSONIC CRUISE AIRCRAFT RESEARCH PROGRAM

Dr. FLETCHER. Mr. Roush, I was not here when the SST was canceled. However, NASA's supersonic cruise aircraft research and technology effort was trimmed down in the fiscal year 1974 congressional action—from about $28 million down to a level of about $11.7 million.

The original plan was designed to understand supersonic technology a lot better than we do now. But it was cut back and has stayed at a relatively low level—about $9 million a year.

I felt rather badly when the Congress decided not to go ahead with the higher level of funding, because I hate to do away with technology that has potential value for the future. If we had gone ahead with that, I think we would be in a better position in two ways: We would be better able to judge the competition, either the Russians or the Europeans; and also we would be in a better position to see whether it made sense for us ever to develop a real economical, noise-free, pollution-free supersonic transport.

My regret is that NASA's supersonic cruise aircraft research program was curtailed.

Right now I think the amount of money in that area, instead of $30 million to $35 million is more like $8 million, and that is, in my judgment, grossly under funded, considering the way the world is moving at the moment.

MATERIALIZATION OF OBJECTS

Mr. ROUSH. Going beyond the SST; are we going to develop some program some day whereby we can, as on "Star Trek," energize objects from one place to another?

Dr. FLETCHER. That is a hard question to answer.

I have no judgment on that. Maybe some others do.

Dr. LOW. I guess the only thing we can say in this appropriations hearing is that NASA is not spending any money on that now.

SYSTEMS TECHNOLOGY PROGRAMS

Mr. ROUSH. On page RD–8–21, under the systems technology programs, the justifications indicate a major funding increase of approximately $17 million.

A large part of this increase is attributable to propulsion systems technology, which goes up from $500,000 in 1975 to $18 million in 1977.

Why this substantial increase; and what is its principal direction?

AIRCRAFT ENERGY EFFICIENCY TECHNOLOGY

Dr. LOVELACE. Mr. Roush, the major increase in that program is associated with the efforts that Dr. Low briefly outlined in his opening remarks related to technology to improve the energy efficiency of propulsion devices.

Two major efforts will be conducted in this area. The first will be an effort on current engines to understand why the fuel consumption performance of engines that we currently use degrades with time and how we may prevent that. These efforts could have a very near-term impact on our ability to improve the efficiency of the aircraft in service.

The second effort is to look at more advanced technology, which will be the next generation of much more fuel-efficient propulsion systems than the fan engines that are currently used on wide-body jets.

Mr. ROUSH. In order to achieve this 10 to 15 percent reduction in cruise fuel consumption you are aiming at, would the airplane industry have to retrofit the existing fleet of planes with new engines or significantly modified engines? The point is, would this savings in fuel be sufficient to offset the cost?

Dr. LOVELACE. The current engine program, Mr. Roush, has been formulated, in fact, on the basis of discussions with the engine manufacturing industry, as well as with the airline operators. It is calculated to attack those parts of that problem could come up with answers on how to improve efficiency in such a manner that the technology could be incorporated into engines as the aircraft go through their normal maintenance process.

The answer, then, is that we would minimize any retrofit costs. We would simply, if I might use an example, replace an old seal with an improved seal that would maintain engine clearances for a longer period of time.

TILT ROTOR RESEARCH AIRCRAFT

Mr. ROUSH. Tilt Rotor Research Aircraft is displayed on page RD 8–36. What are the total funds, since inception, that have been committed to this program, and how would you rate the commercial possibilities of this aircraft design?

Dr. LOVELACE. Mr. Chairman, the total funds that have been committed to this program by NASA are $21.6 million.

I should refresh your memory that this is a joint effort with the U.S. Army.

My personal assessment of the tilt rotor research aircraft as a commercial vehicle is that it is very marginal. It is, of course, designed as a research vehicle. The concept of the tilt rotor vehicle itself may, and probably does, have high commercial potential. However, it would have to be developed and designed for a specific mission.

One aspect of tilt rotor aircraft for commercial application which is kind of interesting, Mr. Chairman, is that, as you know, when most helicopters fly overhead they go "wup, wup, wup, wup," and you can hear this loud noise.

In tilt rotor aircraft, you would hear noise over the airport, but then the propellers would tilt forward, and the lift would be provided by the wings rather than the rotors. You would drastically reduce that "wup, wup" noise as it went over populated areas.

Now, that seems to me to be worth quite a bit in the use of helicopters in urban areas. So I think it has commercial potential. That particular design—the Tilt Rotor Research Aircraft design—may not have commercial potential, but the idea certainly does.

Mr. ROUSH. Then, the money that we have put into this program and might be putting into the program is, in your opinion, well spent?

Dr. FLETCHER. Yes, sir. I think in the long range, something like that is probably going to be used in the helicopter field for short-range transportation of passenger traffic. Dr. Lovelace may disagree with me.

Dr. LOVELACE. I agree with you, Dr. Fletcher.

Mr. ROUSH. I thought you said that the benefits were marginal.

Dr. LOVELACE. Let me clarify this.

The vehicle that we have designed and have under construction is a research vehicle. It will help us answer questions on how a tilt rotor aircraft would operate, the performance parameters, and it could be a precursor to the design of a civil vehicle. It also has military potential a very large potential. But the specific tilt rotor aircraft that we are building is a research vehicle.

Dr. LOW. Could I interject some observations, Mr. Roush?

With very few exceptions, we believe that it is NASA's business to do research either on computers or in wind tunnels or, once in a while, with even whole airplanes. But those airplanes are designed to get research information, test data. They are not designed, by definition, to be commercially viable. We think it is industry's job to bring what we design into a commercially viable airplane.

We would not undertake the research vehicle unless we thought that this technology was needed for the next generation commercial vehicle.

Mr. ROUSH. I appreciate that. But somewhere along the line, we have to come to that point where we either reject or accept that research. The purpose is to arrive at that point.

Dr. LOW. Yes, of course. And in the case of a tilt rotor airplane, the reason we are spending such a large fraction, as a matter of fact, of our total aeronautics budget on this and one or two other research airplanes is because we believe very strongly that that research needs to be done now, in order to make available to the industry the technology that they would need for where we see a gap in the aircraft business.

Mr. ROUSH. I think one of the reasons we have come by this rather famous—or, depending upon how you look at it, infamous—phrase "fly before you buy" is that, apparently, the Department of Defense on occasions made a judgment too soon when they started looking at the research that had been done.

Dr. LOW. In the defense business, more often than not, they will take the next step and actually build what is called a prototype, almost identical to the actual fighter-bomber or bomber that they will build.

NASA does not do that. We stop one step short of that, because we are not our own customer.

Mr. TALCOTT. Mr. Chairman?

Mr. ROUSH. Yes, Mr. Talcott?

Mr. TALCOTT. Can I find out what the thrust of your research is on this tilt rotor aircraft?

Is it to find an aircraft that will fly in a different direction, or will it carry more weight or go faster?

Dr. FLETCHER. Basically, it is a way of taking off vertically, like a helicopter, but flying horizontally, like an airplane.

Mr. TALCOTT. What is the thrust of that?

Airplanes can go up, and they can go down, and they can go fast, and they can go high, and they can carry loads and carry passengers.

Dr. FLETCHER. It is more efficient for the longer ranges and also for commercial purposes, it does not have the noise.

Mr. TALCOTT. That is one of the points I was wondering about. One of the worst points about a helicopter or tilt rotor or short takeoff aircraft is the noise. It is almost intolerable. We can fly straight up, but we cannot tolerate the noise.

Dr. FLETCHER. The noise, if we do it right, and when there is a commercial version, will be confined to the airport. You will not find this "wup, wup" noise at all when the rotors are vertical. The reason is that you do not have this backward; you have actually negative lift for a while as it is going backward.

Mr. TALCOTT. So your research is really, truly general. It is for reducing noise and improving the efficiency and the weight-carrying capability and speed. It is not just a single objective research?

Dr. FLETCHER. That is correct, Mr. Talcott.

Mr. TALCOTT. Could I ask if there is anybody here who is interested, or who is not interested, in the special interests? Anybody in the whole room? Any members of the press or the general public?

I ask this question often, because we hold open meetings for the public, but the public never comes.

TRACKING AND DATA ACQUISITION

Mr. ROUSH. We shall now turn to the Office of Tracking Data Acquisition, on page RD 11–1.

Mr. Truszynski, as of right now, we just have a couple of questions.

The total request for fiscal year 1977 is $258 million. This is an increase of approximately $18 million above the current level for 1976.

TRACKING AND DATA RELAY SATELLITE SYSTEM (TDRSS)

Now, turn to page RD 11–29, where the justifications describe the new tracking and data relay satellite system. The committee has asked you about this system for the past 2 years.

When it was originally proposed, the major question was whether it would be a NASA-owned system or a leased system. NASA opted for a leased system. We asked you last year how your decision looked on the basis of comparative cost. You responded—and I find this on page 486 of the hearings from last year—that: "The leased costs approach, the buy costs on the basis of discounted dollars, and, in essence, the leased versus buy ratio is about equal."

Does it still look that way?

Mr. TRUSZYNSKI. Yes, Mr. Roush. Since last year, we submitted to industry a request for proposal for the leased services. We received those proposals in January 1976. We are now heavily involved in our source evaluation procedure. Because of the confidential nature of these proposals, we cannot openly discuss the specific features of them now.

Mr. ROUSH. They were substantially higher than the estimates?

Mr. TRUSZYNSKI. The costs submitted in the proposals are higher than our earlier in-house estimates and are higher than the original phase 1 estimates that the contractors provided.

However, as I am sure you understand, Mr. Roush, we are a long way from the final numbers on this program. We still have an evaluation, selection, and a considerable negotiation process to go through.

However, on the basis of the information provided in these proposals, we did calculate a revised leased versus purchased ratio, and the ratio remains essentially one; it is actually 0.98. Our conclusion is that the leased approach is still viable.

Mr. ROUSH. Last year you told us this new system would save NASA $30 million a year when it went operational. Is that still the case?

Mr. TRUSZYNSKI. Mr. Roush, this figure will change based upon our final negotiations. I think it is fair to say that we still expect to save tens of millions of dollars annually by utilizing this system instead of our current method.

TDRSS SAVINGS

Mr. ROUSH. I gather from your answer that you are saying that the savings would be less than $30 million a year, but that there still would be a savings?

Mr. TRUSZYNSKI. Yes, indeed.

Mr. ROUSH. Can these two satellites still be designed, built, and put in orbit by 1980?

Mr. TRUSZYNSKI. Yes. We think the current schedule, which calls for operation in early 1980 is still good.

Mr. ROUSH. Could the Shuttle system be operated with the existing tracking network, if funds for a leased system are denied?

Mr. TRUSZYNSKI. Yes, with systems augmentations we can support the Shuttle system with the geographical network that we now have.

We face, however, supporting the Shuttle and Shuttle payload missions with a capability that is significantly restricted. We have described this in the past. As you know, the ground network system provides very sparse coverage for low Earth orbit satellites, on the average of 15 to 18 percent. The primary advantage of a satellite system is that it provides essentially total orbital coverage. One can conduct operations such as the Shuttle flights in a greatly improved and more efficient way. You are not restricted, in terms of the geography, as to where you conduct certain maneuvers or deployments.

The Tracking and Data Relay Satellite System will provide a greatly increased capability in terms of conducting mission operations in general. That is one major benefit of the system. In addition, it will be cost effective by decreasing the number of ground facilities now needed.

Mr. ROUSH. Assuming we move on to the tug, does that make a difference in your answer?

Mr. TRUSZYNSKI. No, Mr. Roush. The tug would operate essentially between low Earth orbit and higher Earth orbits. The currently envisioned tracking and data-gathering satellite system is primarily a support system for the relatively low Earth orbits. While it would provide support to some portions of the tug trajectory, in general,

the tug would be supported from, very likely, a single or two ground stations.

Mr. ROUSH. All right.

CONSTRUCTION OF FACILITIES

We are going to move on now to volume II of your budget estimates and justifications, "Construction of facilities."

On page SUM–4, the table lays out the current NASA construction picture. The request for fiscal year 1977 is $124,020,000, an increase of $41,890,000 above the amount appropriated for fiscal year 1976.

FISCAL YEAR 1978 CONSTRUCTION OF FACILITIES ESTIMATE

What is the anticipated fiscal 1978 construction request?

General CURTIN. $175 million is our current estimate.

FISCAL YEAR 1977 REQUEST TO OMB

Mr. ROUSH. What was NASA's request of OMB for construction?

General CURTIN. $145 million, Mr. Chairman.

Mr. ROUSH. Then certain items were eliminated?

General CURTIN. Yes, they were, to reduce down to the $124 million that is before you today. The $21 million adjustment involved seven items, the largest of which was $10 million to initiate the repowering of the 40-by-80-foot wind tunnel at Ames Research Center. There were a total of seven items involved in the total adjustment.

Mr. ROUSH. Would you supply the seven items for the record?

General CURTIN. I would be glad to.

[The information follows:]

The following are the six reductions made to the fiscal year 1977 COF budget before it was submitted to Congress:

	Millions
Modification of 40- by 80-foot subsonic wind tunnel (ARC)	$10.000
Modifications for applications support facility (GSFC)	1.550
Additional and modifications to Shuttle payload development (GSFC)	2.660
Modifications to launch complex 39 (Shuttle) (KSC)	3.670
Rehabilitation and modification at various locations	2.000
Facility planning and design	1.200
Total	21.080

SIXTY-FOUR METER GOLDSTONE ANTENNA

Mr. ROUSH. Last year, when you were asked the same question, you indicated a major item dropped from the 1976 budget was $21.2 million to start construction of the large 64-meter antenna at Goldstone.

Did you request the same project of OMB?

General CURTIN. That was not requested in this year's program, Mr. Chairman.

Mr. ROUSH. Why not? It was very important last year, or the year before last.

Dr. FLETCHER. Mr. Truszynski could probably answer that, but I know he is going to be very strong for it.

Let me say that in times of stress, you drop the programs that you think you can stand a risk on. What dropping that program means is that, when we have all of these planetary probes on their way, we run the risk of losing data in case one or the other of the large antennas drops out.

Mr. TRUSZYNSKI. Mr. Roush, the situation is as Dr. Fletcher summarized it. If you recall, the reason for our submitting the proposal for an additional 64-meter antenna was just that.

There is a significant continuing workload in the planetary program. Many of the spacecraft are reaching extreme distances. As a result, they require support by the large antennae.

When examining that workload, it became very clear to us that we were going to have to compromise support on the basis of priorities. The decision was made to compromise on the tracking and data support rather than to proceed with an additional antenna.

Mr. ROUSH. But you do feel rather strongly?

I see one head, at least, saying yes.

Dr. FLETCHER. Yes, he feels very strongly about it, Mr. Chairman.

Mr. ROUSH. I might say, Dr. Fletcher, that I appreciate the feeling that I observe on your side of the table. I have so often seen witnesses, who are backup witnesses, have opinions, but when they are asked a question, they look over at the Administrator to see what his reaction to their response might be. They are uptight about responding freely. I appreciate the fact that within your own agency you apparently do have differences of opinion and that you apparently discuss them freely, without letting it interfere with your working relationships. At least it seems that way from this side of the table.

Mr. Talcott, you look as though you are about to say something.

Mr. TALCOTT. I agree with you. I applaud the same things you are applauding.

But I also remember playing on a football team one time, when I could have cursed the quarterback for calling that play. But we still all got in there and worked like the dickens on that play.

Mr. ROUSH. I did not mean to imply they were not. I think this is one of the greatest teams that the country has produced.

Mr. TALCOTT. And they have differences of opinion, and that is great. And when they come to a consensus, that even makes it better, when you know there is a difference of opinion that they all try hard.

SPACE SHUTTLE FACILITIES

Mr. ROUSH. We will now turn to the justification by location. Let us turn to Space Shuttle facilities on page CF 8.

You are requesting $39,825,000 for Space Shuttle facilities in fiscal year 1977. How much of the $300 million in constant 1971 dollars have been provided, if you include the 1977 request?

General CURTIN. Let us see. I will have to add that. That will be $217.7 million, Mr. Chairman. That is, as you indicated, in 1971 dollars, and it relates to the original $300 million commitment that we made some years ago.

Mr. ROUSH. Then you have close to $85 million to go?

General CURTIN. About $78 million yet to go, something on that order of magnitude. Because our present estimate in terms of the 1971

dollars is $295.5 million instead of the $300 million. So the actual difference is $77.8 million, if you want to be precise about it.

Mr. ROUSH. Then you are still staying within the estimate?

General CURTIN. Very definitely, Mr. Chairman.

MODIFICATIONS TO LAUNCH COMPLEX 39

Mr. ROUSH. Turn to page CF 8–13, where NASA is requesting $19,855,000 for continued modifications to launch complex 39 at the Kennedy Space Center.

Now, on page CF 8–14, the justifications describe the need for a second mobile launcher. If I understand correctly, funds have already been provided for a modification of one mobile launcher. Is that correct?

General CURTIN. That is correct.

Mr. ROUSH. The justifications indicate that, after some experience, a single mobile launch platform can support approximately 15 to 16 launches a year. However, you also indicate that in the early phase of Shuttle operations, the capability of a single launcher is somewhat less, largely because it will take some time to learn how to refurbish the mobile launcher after each launch.

TURNAROUND TIME FOR REFURBISHMENT OF MOBILE LAUNCHER

When the initial flights are made in 1979 and 1980, what is your best estimate of the turnaround time necessary for refurbishment of the mobile launcher?

Mr. YARDLEY. You asked the time to refurbish the mobile launcher itself?

Mr. ROUSH. Yes. I am asking, during the period of 1979 and 1980, what is your best estimate of the turnaround time necessary for the refurbishment of the mobile launcher?

Mr. YARDLEY. We think the total turnaround time for the Shuttle and the mobile launcher, when you are operating one Shuttle, will be on the order of 6 to 7 weeks. The mobile launcher itself can be turned around in considerably less time, about 2 weeks.

Mr. ROUSH. This pertains to the initial flights in 1979 and 1980. I guess we were under the impression that it might take longer than that during the initial flights.

Mr. YARDLEY. No; the main thing that takes longer is refurbishing and turning around the orbiter.

General CURTIN. Mr. Chairman, you spoke of the learning curve of getting around to handle 14 to 15 per year with one launcher. There have been some gross estimates that that would take 2 to 3 years before we would be in that posture.

Mr. ROUSH. I gather from your response, then, that the turnaround time of the first mobile launcher would be sufficient to meet the schedule of three development flights in 1979, three additional development flights in 1980, and the initial operational flights scheduled for 1980. Is that correct?

Mr. YARDLEY. Yes.

SECOND MOBILE LAUNCHER

Mr. ROUSH. As a part of the justification for this item, on page CF8–15, you indicate—and this is in the second paragraph—the second mobile launcher must be ready by the fourth quarter of calendar year 1980, when the second orbiter arrives at KSC. The current budget restrictions will not permit the second orbiter to arrive in the fourth quarter of 1980. Is that correct?

Mr. YARDLEY. That is right. It will not be until a few months after that, early 1981.

General CURTIN. We plan to have this activated in the fourth quarter, as you indicated, of calendar year 1980.

Mr. ROUSH. We have one judgment here that there is a slippage of about 3 months, with delivery schedule perhaps in March of 1981. Does that sound correct?

Mr. YARDLEY. March 1981 is our present date on that.

Mr. ROUSH. One page CF 8–17, is the entire $19,855,000 associated with the redesign of the second mobile launcher?

General CURTIN. No; it is not, Mr. Chairman.

Mr. ROUSH. Would you break that down for us?

General CURTIN. Yes, sir. $14,855,000 is associated with the second mobile launcher. There is also $5 million included for dealing with modifications to Pad–A that are associated with the first phase of the solution of acoustic problems that have been encountered in connection with the shuttle lift-off. This will be largely, again, to provide hydropneumatic tanks and piping systems in order to provide water to attenuate the acoustic levels that we now have experienced in wind tunnel tests and feel we will experience on launch.

SOLID ROCKET BOOSTER PROCESSING FACILITIES

Mr. ROUSH. On page CF 8–22, you are requesting $9,700,000 for modifications of solid rocket booster processing facilities. These facilities would be used to process the solid rocket boosters which drop off into the ocean and are recovered and reused. Apparently, you have had some change in approach in getting this job done from what you told us in last year's budget. Is that the case, and if so, could you explain it to the committee in some detail, and tell us how much you saved by making this change?

General CURTIN. Yes, Mr. Chairman. Last year's program was $5,240,000, and as you recall, at the time of the hearings, we envisioned using certain of the Air Force Titan III facilities for this particular phase. Subsequent to submission of that program and in relation to the development of the solid rocket booster design, our concern for the hazards involved with the potential use of the VAB, have been reduced considerably.

We always looked at the possible use of the VAB at Kennedy as being an optimum solution, because of the consolidation of the total operation. But we were initially concerned about the hazards or potential hazards, and therefore went to the use of the Air Force facilities to reduce that concern. As I say, subsequently, because of the devel-

opment, we are now able to reassess that, and we are now going back to use the VAB.

The reassessment permitted this realignment. There will be no total construction funds "saved" in this realinement. There will be, however, improved efficiency and economies in the total day-to-day operations, because of the consolidation I indicated. What we have really done is taken a prior year's program of $5.2 million and reoriented it to the VAB to do the first phase work. And for that reason, the obligation of those funds have slipped somewhat, and this $9.7 million has been integrated into that.

You will recall last year we indicated that about $8 million to $10 million additional would be required as the followon to the $5.2 million in the Air Force facility. This request is of the same order of magnitude. So I think we could say that the facility element of the total cost was about the same.

SHUTTLE CARRIER AIRCRAFT MATING FACILITIES

Mr. ROUSH. On page CF 8–32, you are requesting $2,050,000 to complete the construction of shuttle mating facilities. You had originally intended to construct three mating facilities, one at Palmdale, one at Edwards Air Force Base, and one at Kennedy. As I understand it, you have now decided to scrub the mating facility at Palmdale, and you will tow the Orbiter from Palmdale to Edwards.

Do you want to explain to the committee why you changed your mind on that procedure, and how that change has affected costs?

General CURTIN. First of all, Mr. Chairman, I would like to make the point that the decision, or final decision, has not been made with respect to that. We have released the environmental impact assessment which has been published in the Federal Register. When the inputs from that are received, management will reassess this total problem, and hopefully be able to arrive at a final decision.

Now, if we assume that the decision is favorable downstream, the accounting goes something like this. We have $2.58 million allocated in prior years' appropriations for the work at Palmdale and $350,000 of that has gone into the long-lead procurement of the steel and hoist for that facility. The remaining amount, approximately $2,150,000, will be needed to accommodate the facility work associated with the overland route.

Now, to realine those funds, of course, we would be advising the committee, in the normal process, and would follow along with a normal section 3 action.

Mr. ROUSH. Have you done anything at all toward realining those?

General CURTIN. Nothing formal. We are waiting for the decision.

Mr. ROUSH. Time is running out on the decision, is it not?

Dr. Low. We have to go through the environmental impact process first, and that clock was started about 2 or 3 weeks ago. But until the 67 days are up on the review of the draft environmental impact statement by all concerned parties, we cannot proceed with a formal decision.

Mr. ROUSH. But I assume that the decision has been made, pending a final determination by the Environmental Protection Agency.

Dr. Low. If there are no adverse indications from the environmental impact situation, then yes, we will go overland.

Mr. TALCOTT. So the environmental impact study is not whether to have the mating facilities at Palmdale, but it is to determine whether you can tow it overland.

Dr. FLETCHER. Yes.

Dr. Low. That is right.

Mr. TALCOTT. So you prefer to tow it overland if you can get by the environmental impact statement?

Dr. Low. Yes.

Mr. TALCOTT. And that means changing bridges and a lot of other things?

General CURTIN. Mainly the things that will be involved are building sections of new road, widening existing road, and in certain cases relocating utility lines. The details of this have been worked out at a rather accurate level, and there will also be involved here some real estate easements. These will cover the movement of the Orbiter with the overhang of the wings on adjacent property. And in a very candid way, it is these real estate considerations that give us the major concern, because of the time limits involved.

Mr. TALCOTT. Why did we not think about that in the first place?

General CURTIN. We did. This was looked at initially, and the dollar tradeoffs, as I pointed out in the facility world, were about the same. And then, further considerations have come up; and maybe Mr. Yardley could speak to those.

Mr. YARDLEY. There are actually two things. Last year, our study of the overland route was somewhat more expensive, and we found a better route. Second, in the development of the mating configuration, we did a lot of wind tunnel testing. We know a lot more about it, and we feel a lot more comfortable in taking this first flight of this new, unusual configuration at Edwards Air Force Base, where we have a 27,000-foot runway, and 4 miles of lakebed for overrun. We can get up to flying speed and lift-off, then touch down again. We have got unlimited movement on each side. So it just gives us additional confidence in our first flight.

So, if it is a push, costwise, we would prefer to do it. So that is why we are pushing this right now.

Mr. TALCOTT. That is somethinig I thought you would have considered before. But it looks to me like all the rest of the agencies. You plan on getting to the Moon at the exact time, but you cannot figure how to get overland.

Dr. FLETCHER. We found a better way to get overland, I think, from last year to this year.

General CURTIN. Yes; that is true, too.

Mr. YARDLEY. I might add, we are prepared, if this environmental impact is not satisfactory, to go ahead the way we were. It is just that we found a way with less risk that is not any more expensive, and we think it is incumbent upon us to do that.

Mr. TALCOTT. Thank you.

MODIFICATION OF MANUFACTURING AND FINAL ASSEMBLY FACILITIES FOR EXTERNAL TANKS

Mr. ROUSH. On page CF 8–49, you are requesting $1,930,000 for manufacturing a final assembly facility for Shuttle external tanks. You indicate on page CF 8–52 that an additional $12 million to $15

million will be required to support a production rate of up to 60 external tanks per year. Are all of these funds included in the $300 million 1971 constant dollar estimate?

General CURTIN. Yes; they are.

SPACE SHUTTLE PAYLOAD FACILITIES

Mr. ROUSH. On page CF 9, you outline a new section of the justifications known as "Space Shuttle payload facilities." You are requesting $4,340,000 for this activity in fiscal year 1977. I assume that this is also all part of the $300 million.

General CURTIN. No; it is not, Mr. Chairman. The payload facilities were not involved or included in the $300 million. I believe our earlier assumptions that we outline indicated that.

Mr. ROUSH. Was there a reason for not including them?

Dr. FLETCHER. Mr. Chairman, I probably ought to clarify this. We get into such discussions often, but we intend to separate the payloads that go into this Shuttle from the Shuttle which is a transport. The payloads are the thing that various kinds of users all over the world want to put in orbit. The Shuttle is the transportation system. And all along, we have tried to separate out these two costs. This facility is simply to be able to modify the payloads.

In a way, the Shuttle can be thought of as a freight train, and the payloads can be thought of as the freight, and we keep them quite separate.

Mr. ROUSH. That is well and good. But it is all unique to the Shuttle system, is it not?

Dr. FLETCHER. In one sense. We would not be able to have a Spacelab, for example, if there was not a Shuttle. But on the other hand, we could have a Shuttle without a Spacelab. The Spacelab is just one kind of a payload that can go into the Shuttle.

AMES RESEARCH CENTER

Mr. ROUSH. OK.

Let us go back to page CF 1–2, and we will begin the justification by location with the Ames Research Center. You are requesting $1,220,000 for construction of the high enthalpy—the high energy facility. Is there a current requirement for this facility?

REQUIREMENT FOR HIGH ENTHALPY FACILITY

General CURTIN. There is a current requirement, in the sense that this facility will be used as a tool to do research on the thermodynamic factors involved in the heat shield design for future probes. There is no hard and fast dateline, Mr. Chairman, although we are gearing that to one of the probes.

Dr. HINNERS. The Jupiter Orbiter Probe mission.

Dr. LOW. That is right; the Jupiter Orbiter Probe, to be launched in 1981.

Mr. ROUSH. That was not cut out?

General CURTIN. That has not been approved. But as I understand it, Mr. Chairman, that is the schedule that we have geared this project to.

Mr. LILLY. The Jupiter Orbiter Probe was one of the research and development deferrals in the fiscal year 1977 budget process.

Mr. ROUSH. In view of that, then, could we not wait another year before funding this facility?

Dr. FLETCHER. There is a fixed launch date for the Jupiter Orbiter Probe mission. I think it has to go in 1981.

Dr. HINNERS. Yes; December of 1981.

Dr. FLETCHER. So we would have to do the work earlier than that. We do plan to request funds for a Jupiter Orbiter Probe mission during the fiscal year 1978 budget process.

Mr. ROUSH. I see.

We have no question on the $750,000 for the construction of an addition to the flight control facility at the Flight Research Center.

LUNAR SAMPLE CURATORIAL FACILITY

On page CF 3-2, I notice you are before the committee this year again requesting $2,800,000 for construction of a lunar sample curatorial facility at the Johnson Space Center.

General CURTIN. That is correct.

Mr. ROUSH. Was this not the same project that both the Authorization and the Appropriations Committees denied last year?

General CURTIN. That is correct, Mr. Chairman. This is an update, if you will, of a project we proposed in fiscal year 1976, for $2,490,000. While there have been some minor adjustments in the facility itself, the cost differential basically reflects interim escalation.

Now, last year, if you will recall, there were several questions that arose during the hearings with regard to this facility. One of them involved what we were doing on an interim basis to protect this very valuable, actually priceless, collection of lunar samples. Since that time, since last year's hearings, we have now in operation a remote site at Brooks Air Force Base in San Antonio, Tex. This we have developed in cooperation with the Air Force and it is in an operational status.

We have reviewed again the feasibility of using other facilities at JSC for this purpose, and have reaffirmed our findings that the building of an addition to the building 31 is the best solution, at least that we have been able to come up with.

LOCATION OF LUNAR SAMPLE CURATORIAL FACILITY

Mr. ROUSH. Does this facility have to be at Johnson, or could it be at some other location? Is there any particular reason why it should be at Johnson?

General CURTIN. I think probably two reasons; the first one is that in building 31 we already have a significant portion of the facility we required to provide the total service. More importantly, I think, is the wide spectrum of support activities that Johnson provides to this one activity and, therefore, if it were to be put some place else other than Johnson, you have to find a place that has this capability, both technical and manpower capability, to provide this support. We know of no other place that this could be done as easily.

Mr. ROUSH. Do I understand that the rocks are now being stored at just two places?

General CURTIN. No, they are in the process of going into that posture. There are some samples that are stored in the three vaults

that we indicated last year were being used on a temporary basis at JSC.

Dr. Dow. Let me bring you up to date on the status.

As of this morning, 15 percent of the lunar samples—and this was our plan—have been moved to the Brooks Air Force Base for a remote safe storage. This is more or less of a dead storage, to protect them should any major catastrophe happen at Houston.

At Johnson Space Center, there are several vaults throughout the Center with samples stored. But the remaining 85 percent of the samples are being distributed.

Dr. FLETCHER. There are two major locations.

Mr. ROUSH. Are there 150 principal investigators using those samples at Johnson; or are the samples removed to other locations for their examination?

Dr. LOW. A large faction of the investigative samples are sent to the laboratories of the investigators and then brought back to Houston when the investigators are finished with them.

Mr. ROUSH. What sort of precautions are taken?

Dr. FLETCHER. Extreme precautions, Mr. Chairman.

We account for every gram of that lunar material. Because of its rare nature, we have no idea what the value is, but it could be extremely valuable in terms of dollars per ounce. We have a bookkeeping system and a security system that tracks all of this.

Now, of course, there is always the possibility of a robbery, but so far that has not occurred.

Mr. ROUSH. And do you impose upon the user rather strict security requirements?

Dr. FLETCHER. Yes, we do.

Dr. HINNERS. Very strict.

NEED FOR LUNAR SAMPLE CURATORIAL FACILITY AT JSC

General CURTIN. That particular aspect you are touching on now, Mr. Chairman, was involved in this project, and that is to provide larger space and better capability to handle this large number of samples. As I believe we indicated in the documentation whereas we were dealing initially with about 2,000 items, the number has increased to about 46,000 today, and it is continuing to increase as the investigators work on the samples.

So it is a terrific problem.

Mr. ROUSH. I notice on the middle of page CF 3-3 that building 31 offers very little protection from heavy storms, especially those involving tornadoes, floods and hurricanes, ground shock waves, sabotage or vandalism.

Has a hurricane ever struck the Johnson Spacecraft Center?

Dr. LOW. Yes. Hurricane Carla in 1961, just before the Center was built.

Mr. ROUSH. Would the building you are proposing be hurricane proof?

General CURTIN. Yes, sir.

Mr. ROUSH. How about tornadoes? Have tornadoes ever struck that area?

Dr. FLETCHER. We don't go that far back in history. We could check it out for you.

Mr. ROUSH. Is that area prone to having tornadoes?

Dr. FLETCHER. Hurricanes are very common; flooding is very common. I can't answer your question about tornadoes.

Mr. ROUSH. In the early years of my life I lived in Oklahoma, and everyone had a storm cellar because of tornadoes.

Dr. LOW. I think a tornado in that part of Houston would be an exception rather than a common thing, as it would be in Oklahoma or Kansas.

Mr. TALCOTT. Hurricanes, tornadoes, floods. Boy, what a wonderful location you selected.

Mr. ROUSH. We have no questions now on the projects proposed for the Kennedy Space Center.

LANGLEY RESEARCH CENTER

We will turn to page FC 5–7 and the Langley Research Center where NASA is requesting for fiscal year 1977 $6,185,000 for three distinct projects.

LANGLEY DATA REDUCTION CENTER ANNEX

On page CF 5–7, you are requesting $2,970,000 for construction of a data reduction center annex at Langley.

The justifications indicate that substantial new requirements for computational support continue to grow. But the Langley Center is one of those centers that is being required to absorb a healthy amount of the 500-position cut imposed by OMB.

Is that correct?

Dr. LOW. They had an actual cut in the ceiling of about 158 in the civil service.

Mr. ROUSH. Why are we building new facilities and expanding capacity at this Center where the employment is declining?

Dr. FLETCHER. The employment is declining, primarily, among other reasons, because of the phasing down of the the Viking project, and there is less need for the manpower to manage that very large project.

There are other reasons for the decline, but that is the main one.

Mr. ROUSH. Have you very carefully examined all other potential space at Langley where this computer complex could be installed?

General CURTIN. Yes, sir, Mr. Chairman.

Mr. ROUSH. Are there alternatives?

General CURTIN. There are no other viable alternatives, Mr. Chairman.

As you know, the housing capabilities at Langley have been limited over the years. In fact, a few years back the committee approved a systems engineering building to help us meet, even at that time, a proportion of the office space and lab space requirements.

This is also geared to accommodate the very sensitive equipment, the installation of the Star computer and follow-on equipment. We have been able to improvise, if you will, by shorehorning in equipment over the years. We have now gotten to the point that, as we see it, out in the 1979–80 time period things are going to be extremely

critical unless this project is approved and we are able to really reorganize and reorient our total data processing setup at Langley.

Mr. ROUSH. How much per square foot would the new building cost?

General CURTIN. The building itself is running at about $77 a square foot, Mr. Chairman, which is, admittedly, a little bit on the high side of what I would like to see for a building of this type.

We have reviewed these estimates in considerable detail. I hope that when we finally get the final design completed and the bids in that it will be somewhat lower than this, but this is the best estimate we have at the moment.

Mr. ROUSH. I just looked at plans for another computer facility, and the cost for that was $62 per square foot.

General CURTIN. Yes, $62 per square foot would probably be a good figure for laboratory-type space, and I would say $60 to $70 is a good figure. That is why, in my judgment, this is a little on the high side.

But in going over this in its very preliminary stage, I have not been able to find any elements that I would feel comfortable in reducing.

Mr. ROUSH. I think we all appreciate that there are requirements in a building housing computers; but we are also very cost conscious.

General CURTIN. I assure you that no more will be spent on this than we actually have to.

CONSTRUCTION COSTS

Mr. ROUSH. Does the cost of construction vary substantially from one section of the country to another?

For example, would it be more expensive to construct such a facility in Chicago, Ill., than it would be to construct it here at Langley?

General CURTIN. I can't speak to Chicago, specifically, but in the broad spectrum of facilities that we have in NASA, I would say we are dealing largely with about a 10- to 15-percent variation from one center to the other.

The biggest consideration that we have today is the local impact that escalation will have. This is perhaps the biggest variable we would have throughout the country, and right now it appears to us that that is probably going to be higher on the west coast, affecting Ames and JPL.

The construction index also varies from center to center. And using Washington, say, as a 1, Dryden Flight Research Center in California would probably be on the order of 1.15, to give an example of how we are dealing with it.

LANGLEY—NATIONAL TRANSONIC FACILITY

Mr. ROUSH. If there are no questions for projects proposed at the Lewis Research Center, we will turn to the large aeronautical facility proposed for construction at Langley, and for which a first-year increment of $25 million is being requested.

The National Transonic Facility proposed for construction in this budget is a combination of two facilities; one, a transonic wind tunnel; another, a high Reynolds number tunnel, which originally DOD had planned to construct at the Arnold Engineering Development Center in Tullahoma, Tenn.

What was the total estimated cost of the Arnold facility, when it was considered as a separate project, and what is the total cost of the combined transonic tunnel, and how much will be saved by combining the two facilities?

Is there any performance loss by combining the two?

General CURTIN. Let me try to deal with the figures first.

If I recall correctly, the figures the Air Force was dealing with when they became concerned about the cost was something on the order of $96 to $100 million for the facility. At that time they had designated it as HIRT and it was proposed for Arnold. We were looking at a facility on the order of $35 million at Langley; and at that point in time the $35 million facility cost estimate was a very preliminary figure. There were some indications that that might grow, and I think it was at that point in time that it was decided that we had better look again at the question of whether one facility could best solve the needs of both agencies.

Dr. LOW. It is not combining two capabilities, Mr. Chairman; but both the Air Force and we had planned to build a high Reynolds number transonic facility—we for research purposes and the Air Force for developmental purposes.

The Air Force concept was using the then-existing concept for such a facility. Our people at Langley came up with a new concept where you run the air at a very cold temperature and, therefore, can build a less expensive facility to achieve the same objective—in fact, achieve more objectives, because one of the important parameters is how long the facility can run with one model at a time.

The Air Force facility could only run for a few seconds at a time. The research facility of NASA's with a new concept could run for many, many minutes, which makes it more economical and more powerful as a research tool, because then you can change conditions during a single run.

We got together with the Department of Defense, and after some rather serious negotiations, and after a task team looked at the details, we decided we could combine our two requirements into one and build a single facility for the country instead of two.

I think by the time all of the cost estimates for both facilities would have been in, together we probably would have spent something like $165 to $170 million: on the order of $100 million for the Air Force facility, on the order of $65 million for the NASA facility. By combining the requirements into one, we are proposing to build the one facility at Langley, with complete agreement from the Department of Defense, for a total cost of $65 million.

Mr. ROUSH. Is there any loss of performance?

Dr. LOW. There is no loss of performance, Mr. Chairman.

Dr. FLETCHER. Actually, a gain.

Dr. LOW. There is a gain in performance, but certainly a loss of the total facility running time available. But we have worked this out with the Department of Defense. We both feel we can use this one facility.

REASONS FOR LOCATING THE NATIONAL TRANSONIC FACILITY AT LANGLEY

Mr. ROUSH. Why was the facility located at Langley rather than at Arnold?

Dr. Low. We had a task team made up of both Air Force and NASA people looking at this. I think there were two decisions that resulted in the decision to locate the NTF at Langley.

One—and I think most important—the research people who would be using this facility, who invented the facility, were the Langley people; the development activity at Arnold would have involved research teams coming in from all over the country.

Secondly, we are modifying an existing old wind tunnel, but we are using part of it—we are using the electrical variant system—and that made it an advantage to go to Langley, too. Although on the total economic basis, I don't think the economic effect would have been very different in terms of going from one place over to the other.

PERCENTAGE OF FACILITY USE

Mr. Roush. What will be the percentage of use of the facility; how much for NASA and how much for DOD?

General Curtin. The estimate we have at the present time is about 40 percent NASA, 40 percent DOD, and about 20 percent for industry and the scientific community.

EUROPEAN CAPABILITIES

Mr. Roush. Are the Europeans beginning work on a similar tunnel?

General Curtin. I have no knowledge of that.

Dr. Lovelace. The Europeans have a study group, made up of the Dutch, French, German, and English, examining their requirements and how they might meet them. They have no firm plans to date.

DECENTRALIZATION FROM WASHINGTON

Mr. Talcott. Does NASA consider itself under the constraint of trying to decentralize from the Washington metropolitan area, and do you feel you are exempt from that effort?

Dr. Fletcher. We are not under any constraint, Mr. Talcott. But we have made a conscious effort to move people out of headquarters into the Centers where a good bit of the work is going on. Headquarters does the planning and the integration, and the centers actually do the research and manage the development.

Mr. Talcott. But there seems to be a magnet to build everything as close to Washington, and we think this is counterproductive, not only to the function itself, but to the whole environment of our area and the effectiveness of the Government, in general.

Dr. Fletcher. We are going in just the opposite direction. We are building in California and southern Virginia.

Mr. Talcott. It is a pretty big operation.

Dr. Low. Langley is down in southern Virginia, down by Norfolk.

NASA–DOD ROLE IN AERONAUTICAL FACILITIES

Mr. Roush. Is DOD providing any of the cost of constructing this facility?

Dr. Fletcher. No.

Mr. Roush. Why not?

Dr. FLETCHER. Because we have a joint program with DOD in which they pay for some facilities and we pay for others. They are building a much larger facility, which we are going to use, in Tullahoma—a large propulsion facility, and the cost of that is estimated at $437 million. They are doing more than their share in the total integrated plan.

NASA–DOD COORDINATION

Dr. LOW. We are well coordinated, Mr. Chairman, through a mechanism called the Astronautics and Aeronautics Board, and I think this is a good example of this coordination, because if we didn't have it, we would have built two separate facilities.

Mr. ROUSH. I can remember way back when the committee was asking these questons, when they were asking why you were not better coordinated—a long time ago—why the duplication of effort between NASA and DOD; and it's good to see that you are coordinated on this particular effort.

AMES—40- BY 80-FOOT WIND TUNNEL MODIFICATIONS

Going back to page CF 7–1, again, the justifications note the originally planned modification of the 40-foot by 80-foot subsonic wind tunnel at the Ames Research Center.

Now, this project was included in the House authorization bill for fiscal year 1976, but the appropriations bill specifically denied any reprograming of funds for starting the modification until it had been justified before this committee.

REQUEST TO OMB

As I understand it, you went to OMB with a request for initial funding for both of these projects; is that correct?

Dr. FLETCHER. That is correct.

Mr. ROUSH. What was the amount of that request?

Dr. FLETCHER. $10 million for fiscal year 1977 to initiate the mods.

ESTIMATED COST OF 40- BY 80-FOOT MODS

Mr. ROUSH. What is the total estimated cost of a 40- by 80-foot modification?

General CURTIN. We actually consider it in two phases, Mr. Chairman. One is a repowering phase and with a fiscal year 1977 start it was estimated at $36 million. And the second phase, which involved the building of a new leg, was estimated in the future to be in the range of $45 million to $50 million, depending upon the time frame in which it was built.

OMB VIEWS ON 40- BY 80-FOOT MODS

Mr. ROUSH. If the committee—and I want you to understand, now, that we are just speculating—but if the committee were to provide you with some authority to reprogram existing funds to begin work on this project, what would you estimate your chances are that OMB would approve such a reprograming in fiscal year 1977?

Dr. FLETCHER. OMB never gives advance indication of what they will be willing to reprogram; and I think this would hold in this case as well.

Again, we could ask them, for the record, if you would like, Mr. Chairman.

Mr. ROUSH. Yes, we would.

[The information follows:]

OMB personnel informed us that it would not be possible for them to take a definitive position at this time. It was their opinion that, given the fiscal conditions existing at the time the decison was made to defer initiation of the 40-foot by 80-foot modifications, that the decision made was a correct one. Although they are not currently aware of any NASA funding that they would consider available or justified for such reprograming, they would, of course, as always give serious consideration to the views of the Appropriation Committee and the Congress.

Mr. ROUSH. How important is the modification of the wind tunnel at Ames, the 40-foot by 80-foot?

Dr. FLETCHER. I can answer that, but I think that Dr. Lovelace will want to amplify.

It is extremely important for us for the testing of large vehicles, particularly rotary wing aircraft. You can put whole helicopters in this tunnel when it gets modified, and you can test them at higher speeds when it gets repowered. This is the largest facility in the country right now, and it may get slightly larger. We could accommodate most of the new rotary wing aircraft that are anticipated.

You might want to elaborate on that, Dr. Lovelace.

HELICOPTER MARKET

Dr. LOW. Let me make a few comments first.

I showed on the chart yesterday that the United States is rapidly losing ground on the world helicopter market. We had 80 percent of the share of that market 10 years ago; we only have 40 percent of the share now.

Second, helicopters are becoming important in this country, not only for short-range transportation but also for providing transportation out to oil rigs. As oil rigs move farther and farther out, this is the way they are being resupplied, and people move back and forth to them. So the helicopter picture is an important one, and we consider this facility an important one to go along with the future of helicopters.

Dr. LOVELACE. I would just amplify Dr. Low's remark and indicate that the repowering phase, the first phase, will get us the speed capability of 300 knots, which the French already have in their Modane facilities. That is a tool that they are using effectively in the designs of the aircraft that are causing competition.

Our test capability in the 40-foot by 80-foot right now is substantially below that of the known Russian capability in this area. So that in both V/STOL and the helicopter area, applications of this modification will get us in a competitive testing capability.

EUROPEAN USE OF U.S. AERONAUTICAL FACILITIES

Mr. ROUSH. Do the Europeans, more specifically the French, ever use our facilities?

Dr. LOVELACE. The French have not, to my knowledge, used our facilities in the last few years. We have had some discussion with them regarding the use of certain test facilities.

Mr. ROUSH. Have those discussions included the possibility of us using their facilities?

Dr. LOVELACE. Yes, sir.

Mr. ROUSH. What are the results?

Dr. LOVELACE. We have not concluded the discussions with the French. The practical matter—let me say the difficulty of it—comes down to this: We are reluctant to consider the testing of proprietary industrial designs. And unless we can find some way to come to grips with that problem, our industry will find it difficult to use foreign test facilities. We will dedicate, as was indicated, in the national transonic facility a fraction of the time for use by the commercial community of the United States.

Mr. ROUSH. Do you not find that there is reluctance on the part of the individual inventor and designer to permit you or permit ERDA or anyone else to test something that he or she may have developed?

I find that—you know, all of us who are Members of Congress receive communications from people about so and so who invented a carburetor.

Mr. TALCOTT. We know lots of inventors.

Mr. ROUSH. I have one in my area; the fellow has an automobile—I think it is an Olds 88; I have ridden in the car, and I have seen the tests. The day I rode in it, it was getting, I think, 38 miles to a gallon of gas. He has now modified it, and there is no emission problem whatsoever with his design. And he wants to, and I have advised him to, protect his proprietary rights. But he is hesitant.

Dr. LOW. There is one exception to that, Mr. Roush. That is the NACA–NASA wind tunnel program. This is because we built, ever since 1950, the reputation with industry that we will, indeed, protect their designs completely and absolutely when they test them in our wind tunnels. It takes many, many years to build this kind of a reputation and establish this kind of credibility.

But I think we have it. And it is continuing in the NASA wind tunnels.

Mr. TALCOTT. It takes a whale of a lot of money, more than Ed's friend can ever accumulate, to build a wind tunnel.

Mr. ROUSH. Yes, I have been in the facility at Ames. It is an awesome thing to stand in. I am rather alarmed that someone might pull the wrong switch or something while I am standing in there. It really is awesome. And I appreciate the fact that it is a very valuable asset to our technology in this country.

Mr. TALCOTT. It appears that you are developing helicopters solely for oil exploration out on the Pacific coast. I would like to suggest that helicopters are extraordinarily valuable for research and rescue and helping people in emergencies, much better than any other vehicle we have. We desperately need more of them.

Dr. FLETCHER. It is a very rapidly growing industry, the helicopter business. A great deal of competition is coming from Europe.

SHUTTLE FACILITY PLANNING AND DESIGN

Mr. ROUSH. Unless there are questions on the modification of facilities or minor construction of facilities, let us turn to page CF 12–6,

where you are requesting $2,900,000 for Shuttle facility planning and design.

Are those funds considered as part of the $300 million total?

General CURTIN. Yes, they are, Mr. Chairman.

INFRARED TELESCOPE

Mr. ROUSH. Now, let us raise an issue that takes us back to a project that was funded in fiscal year 1975, and that is the infrared telescope facility in Hawaii. The committee learned through a non-NASA source that a major problem has been encountered with this project.

Simply put, the problem was that the primary mirror blank cracked at the optical shop of the Kitt Peak National Observatory. When this project was sold to the committee 2 years ago, it was done so largely on the basis that the telescope was required for the Mariner-Jupiter-Saturn 1977 mission.

I am quoting from the hearing record. Dr. Fletcher, you said, "Although there would be a broader use of the telescope, the main reason NASA has to have it in this time frame is for the Mariner-Jupiter-Saturn 1977 mission."

First, is there a problem?

Dr. FLETCHER. Yes, there was a problem on the cracked mirror, Mr. Chairman.

Mr. ROUSH. We did not hear about the problems from NASA. We heard about them from another source. But, more important, the fact is that the telescope will now not be ready prior to the launch of the Mariner-Jupiter-Saturn mission in the fall of 1977.

Our information is that the telescope will probably not be ready until 1979 at the earliest. So, therefore, it is quite possible that the telescope will not even be available for the Jupiter encounter.

This seems to me to change the basis for the justification. Why should the committee not cancel the project now?

Dr. FLETCHER. Mr. Chairman, first of all, I want to apologize for your receiving the information about the cracked mirror from some other source. We should have told you about that when it happened, but it was in all the papers, and we assumed this was common knowledge.

Second, we have a plan for recovering and meeting the schedule, which will be ready in time for the MJS mission. It will not be ready, probably, before the launch, but it will certainly be ready before we encounter the first planet, Jupiter, in time to make orbit changes as we discover things about the planets and the nature of the satellites themselves.

You see, Jupiter has a large number of satellites that we also want to observe with that telescope. But in addition to that, I think it is 3 years before we go on to the planet Saturn. During that entire 3-year period, we will be watching it with the infrared telescope.

We do not have a firm plan at the moment—or maybe we do, and Dr. Hinners can correct me. But very shortly we will come back with a firm plan with all of these dates and with any increase or changes in costs, which will show you how that telescope will be used, indeed, on this high-priority MJS mission.

INFRARED TELESCOPE SCHEDULE

Mr. ROUSH. Dr. Hinners.

Dr. HINNERS. Yes. with the new mirror, we now project we could have this on schedule by the late summer of 1978. Jupiter comes into observing position again in October of 1978, so we would have about a 6-month period there before the encounter of Jupiter, the earliest of which would be in March of 1979. So we will have a good observing period to do the targeting of the Mariner-Jupiter-Saturn instruments for Jupiter before the encounter.

We are refining that, but we think we can meet that date.

General CURTIN. Mr. Chairman, may I make a point?

Mr. ROUSH. Yes.

General CURTIN. I do not mean to be argumentative at this point, but if my memory serves me correctly, this subject was a matter of general discussion in one of our meetings with the staff. It probably was lost in the shuffle with lots of other items. But we have made, I think, a very conscientious effort to keep the staff informed of these things. I would have to go back and refresh my memory as to the details of this.

Dr. FLETCHER. Maybe we could provide for the record any information or discussions that we had. If we did not do it, if it turns out that it is not in the record, let me just apologize in advance for not doing so.

General CURTIN. It certainly was our intent to do so.

Mr. ROUSH. I am glad to hear that. I think the committee does not expect too much, but when there is a disruption of what is a major program and it does hit the newspapers, I would think you would be clamoring to explain to us what had happened, in view of the fact that we must explain the funding and why we should go ahead with the fundings.

You have responded to the questions as to why we should go ahead.

Dr. FLETCHER. I certainly agree. In defense, we tend to want to have the solution before we tell you what our problems are. But we really should not do that.

Mr. ROUSH. Mrs. Burke, do you have any questions?

Mrs. BURKE. I have none.

Mr. ROUSH. Mr. Talcott?

Mr. TALCOTT. What do you do with a cracked mirror?

Dr. FLETCHER. I do not know what they plan to do with it.

General CURTIN. This will probably be used for regrinding and reshaping into smaller lenses. This is being examined now. But that is the normal disposition.

Mr. TALCOTT. It is just like a diamond? If it gets cracked, you break it up and make smaller ones out of it?

General CURTIN. That is correct.

RESEARCH AND PROGRAM MANAGEMENT

Mr. ROUSH. We are going to turn to volume III now. We will turn to pages SUM–1 through 16. We will first raise some of the general points.

Dr. FLETCHER. May I say we have now at the table Mr. Ray Kline, Assistant Administrator for Institutional Management, who is substituting for Elmer Groo. He will address some of your questions.

Mr. ROUSCH. On page SUM–2, the justifications lay out the basic funding for reseach and program management, excluding the pending supplemental appropriations.

The total provided in fiscal year 1976 is $775,512,000. This was a reduction of $488,000, to compensate for a 10 percent cut in GSA's space rental charges.

You are currently requesting $19,986,000 in the spring supplemental for pay costs associated with last October's 5-percent pay increase. You are also requesting $7,117,000 in the transition quarter for the same purpose. The 1977 request of $814,055,000 includes approximately $27 millioin to annualize last October's pay increase.

NASA CIVIL SERVICE DECREASE

Now, if we turn for a moment to page SUM–13, we can see the effect of the 500 position decrease in the total NASA employment. The current estimate for fiscal year 1976 is 24,316 permanent positions, and the fiscal year 1977 estimate is 23,816.

PERSONNEL AND RELATED COSTS

Now, turn back to page 3. Here we can see that personnel and related costs show a decline of about $4 million from the current estimate for fiscal year 1976. Is that directly attributable to the 500 position reduction?

Mr. KLINE. Yes; it is, sir.

Mr. ROUSH. If the base shows a decrease showing the 500 position reduction, why does the annualized cost of October 1975 pay raise not also show a proportionate reduction?

Dr. LOW. In 1976 this was included for only 9 months, while it is effective for a full year in 1977.

Mr. LILLY. A more comparable number would be to add the fiscal year 1976 estimate with the transition quarter and compare that with the fiscal year 1977 requirement.

Mr. ROUSH. OK.

When the numbers on page 3 are analyzed, you find that the monthly cost of the October 1975 pay increase based on $19,986,000 for the first 9 months is $2,221,000. The monthtly rate of $27,055,000 requested for fiscal 1977 is $2,254,000.

The point is: Why is the rate higher in 1977 than in 1976, when the agency's total permanent positions are declining?

Mr. LILLY. We would be glad to provide an analysis for you. The pay raise was not effective until the middle of October. Ours was not effective until the middle of October, but we would be glad to provide a detailed analysis.

Mr. ROUSH. Would you provide that for the record?

Mr. LILLY. Yes, sir, I will.

[The information follows:]

The pay raise was effective on October 12, 1975, making it effective for 8.7 months in fiscal year 1976 and for 12 months in fiscal year 1977. Dividing the effective months per year into the pay raise amounts for each year yields the rates below, showing a decline from 1976 to 1977 pay raise rates.

[Dollar amounts in thousands]

	Fiscal year—	
	1976	1977
Months effective	8.7	12
Pay raise amount	$19,986	$27,055
Monthly rate	$2,297	$2,254

Mr. ROUSH. I believe there is one less paid day in fiscal year 1977 than there was in fiscal year 1976. Have you taken that into account?

Mr. KLINE. Yes, we have, and that additional day costs about $2,132,000.

Mr. ROUSH. Also, why does it cost $150,000 more per month in the transition quarter for pay raise costs than it does for the same number of people in 1976? The monthly rate of $7,117,000 is about $150,000 above the monthly rate of $19,986,000.

Mr. KLINE. During the transition quarter, we have other personnel costs that are taken into acount that raises our rate somewhat. Specifically, the cost of nonpermanent summer employment is picked up during that period for the entire year.

Mr. LILLY. Mr. Chairman—again, if you wish, we will be glad to provide for the record an analysis of the transition quarter. As you know, monthly increment comparisons, are somewhat misleading. It depends on the number of paydays. Some months have more paydays than others.

Mr. ROUSH. Are you aware that the Budget Committee's concurrent resolution assumes at least a 10-percent reduction of pay cost?

Mr. LILLY. In fiscal year 1977?

Mr. ROUSH. If you were not, you are now. That is for 1976.

Dr. FLETCHER. That must have happened recently.

CURRENT PLAN FOR CIVIL SERVICE REDUCTION

Mr. ROUSH. Will most of the reduction of 500 positions be accomplished in the last quarter of fiscal 1977, or do you expect the reduction to be more gradual during the entire fiscal year?

Mr. KLINE. The plan for a scheduled reduction is that they will take place at all the centers except at the Marshall Space Flight Center prior to the beginning of fiscal year 1977. At Marshall, the 188 reduction at that center will take place before the completion of fiscal year 1977.

Mr. ROUSH. If you will provide for the record your current estimated plan of the 500 reduction by month, beginning in October of this year.

[The information follows:]

The number of position reductions each month, beginning in October, is as follows: October—45; November—25; December—20; January—20; February—20; March—25; April—45; May—50; June—75; July—75; August—60; and September—40.

Mr. ROUSH. Then, no page SUM–4, under the itemized reductions, cost item "b" indicates you save $5.5 million owing to revisions in the Civil Service personnel plan for fiscal year 1976. How were you able to save $5.5 million in personnel costs, when you had the same number of people on board in fiscal year 1975 as you show in fiscal year 1976?

Mr. KLINE. For fiscal year 1976 we were not able to forecast, at the time that the original budget was developed, that exceptionally high number of retirements. Over 700 people, generally high-salaried, went out. Many of the replacements came in at entrance pay levels, grade levels 5 through 9 for professionals, and technicians at grade levels 2 through 4.

In addition to that, we delayed filling the vacancies, which accounts for about $1.8 million of the reduction. We generally tightened up because of the constraints of our budget during that period of time.

Mr. ROUSH. When you speak of the high rate of retirement, were these voluntary retirements? Were they early retirements?

Mr. KLINE. We had a number of people who took advantage of the "early out" retirement option that became available.

Mr. ROUSH. Is there an additional cost incurred to the Government when they take the early out?

Mr. KLINE. Not to the agency.

Dr. FLETCHER. Not to NASA, but to the retirement fund.

Mr. ROUSH. That cost is not assessed against your agency, then?

Mr. LILLY. The cost of any accrued leave or "back pay" would, of course, be paid by the Agency during that time period. But in terms of the retirement pay as such, no. That comes out of the retirement fund.

Mr. KLINE. If you mean in the context of severance pay or something like that, there was no severance pay involved.

DISTRIBUTION OF PERMANENT CIVIL SERVICE POSITIONS BY INSTALLATION

Mr. ROUSH. OK.

Turning to page SUM–12, where the justifications lay out the breakdown of permanent positions, it shows the 500-position reduction will be absorbed principally at four centers—Marshall, Goddard, Ames, and Langley. Why is that?

Mr. KLINE. This is the direct result of an institutional assessment that the Administrator asked that we conduct, starting last spring. We have gone through a project-by-project analysis of the work being done and planned at each of the centers, leading to some consolidation of activities at some of the centers. Having done that on a program-by-program analysis basis, we then identified an indirect increment of manpower attributable to the programmatic changes. When you net all of that together, it came out in the pattern you see.

We did not make a pro rata reduction at all the centers in applying the overall reduction. It was done selectively, based on specific decisions in programmatic areas regarding what work the individual centers would be pursuing.

AERONAUTICS CIVIL SERVICE POSITIONS

Mr. ROUSH. Three of those centers are heavily engaged in aeronautical work. Are any of these job reductions in any way related, directly or indirectly, to aeronautical work?

Mr. KLINE. Generally, the aeronautics effort reflects a net drop of only 42 positions, agencywide. So the general answer is that agencywide aeronautics will remain essentially at the same level as the preceding year.

Mr. ROUSH. You say only 42 positions out of how many?

Dr. LOW. About 3,800.

Dr. LOVELACE. The reduction represents about 1 percent.

Mr. KLINE. About 3,800 of our Civil Service personnel are in aeronautics work.

Mr. ROUSH. Of the total number of civil service permanent positions, 23,816, planned by the end of fiscal year 1977, what number represented—directly or indirectly—working on the Space Shuttle, including associated areas such as Spacelab, payload definition, et cetera? You can provide that for the record, if you will.

[The information follows:]

The direct civil service positions planned for fiscal year 1977 for the applicable efforts are as follows:

	Direct CS positions
Shuttle	5,340
Interim upper stage	88
Spacelab	305
Payload integration and mission analysis	232

SPACE SHUTTLE CIVIL SERVICE POSITIONS

Mr. KLINE. Mr. Chairman, if you will, on the next page, you will see that the fiscal year 1977 permanent civil service positions for the Space Shuttle will be 5,340.

Mr. LILLY. Of course, we will supply the Spacelab and payload data that you requested for the record, Mr. Chairman.

Mr. ROUSH. Could you also provide for the record a similar percentage of total positions for fiscal year 1972, indicating what percentage of the total NASA employment was committed to manned space operations?

Dr. FLETCHER. I think we could do that.

[The information follows:]

In fiscal year 1972, 30 percent of the total permanent civil service positions were dedicated to manned space flight programs.

JOHNSON SPACE CENTER (JSC)

Mr. ROUSH. OK. Now, we shall turn to the justifications by installation, beginning with the Johnson Space Center. On RPM 1–8, the justifications outline travel costs for the Johnson Space Center. You note that you were able to make some savings in the fiscal year 1976 travel estimate through economies, including telephone conferences. On the other hand, the fiscal year 1977 budget estimate shows an increase in travel above the current fiscal year 1976 estimate. Would you provide for the record actual travel costs through January 31 for fiscal year 1976?

Mr. LILLY. Yes, sir.

[The information follows:]

Travel function actual obligation for fiscal year 1976 through January 31, 1976, for JSC is $1,828,000.

JSC TRAVEL COSTS

Mr. ROUSH. Why is the annual rate of travel higher in the transition quarter, substantially higher, than either 1976 or 1977?

Mr. KLINE. The transition quarter is the time period during which the major Shuttle Orbiter approach and landing test buildup takes place at the Dryden Flight Research Center. A large number of people from the Johnson Space Flight Center are required to be there and participate in that particular effort. That activity accounts for most of that increased travel requirement.

KENNEDY SPACE CENTER—MAINTENANCE

Mr. ROUSH. Now turning back to the Kennedy Space Center, on page RPM 2–1, and then referring to RPM 2–10, under "Maintenance and related services," the justifications indicate you were able to save substantial funds over what you had requested for maintenance and grounds for 1976. In the last paragraph on that page, it indicates that the decrease reflects a reduction of 71 support contract or man-years. How were you able to mke that reduction?

Mr. KLINE. This is an effort at the Kenedy Space Center to reduce the level of effort for the maintenance of buildings grounds in an attempt to balance all requirements during a period of increasing prices that the Center has had to contend with during that same period of time.

Mr. ROUSH. Has maintenance of any building or buildings been decreased or discontinued?

Mr. KLINE. There is a decreased level of maintenance effort at the Center. It is an area of particular concern at all of the Centers. All the Center Directors are concerned about it, but in the face of support contract wage increases and increased utility costs, we have had to make some adjustments at all of the Centers. This action at KSC is the type of thing we have to do to meet those kind of problems.

Mr. ROUSH. When did the contractor wage increases occur in 1976, and what was the percentage of increase?

Mr. KLINE. They increased throughout the year. In 1976, the wage increases Agency-wide were over 8 percent. Our forecast for 1977 is, they will go up another 7.8 percent. This forecast is based on a detailed analysis of the actual wage agreements that have been consummated. This includes the collective bargaining agreements between the unions and the contractors and the wage determinations made by the Department of Labor; these increases take place at different points through the year, depending upon the term of the contract.

Mr. TALCOTT. Mr. Chairman?

Mr. ROUSH. Mr. Talcott?

BICENTENNIAL EXPOSITION ON SCIENCE AND TECHNOLOGY

Mr. TALCOTT. Will maintenance at KSC have to be increased this year to take care of the huge Bicentennial event?

Mr. KLINE. We do forecast some increase for maintenance at KSC, but not because of the Bicentennial Fair.

Mr. LILLY. On the matter of the Bicentennial, NASA selected by the President to host at the Kennedy Space Center a Bicentennial Exposition on Science and Technology. We were provided, through the Department of Commerce appropriation for economic develop-

ment, with $3 million to provide the necessary facilities and outfitting to conduct this exposition.

Mr. TALCOTT. This is really not your show? It is Commerce's show?

Mr. LILLY. The Department of Commerce provided funds for the facility work that is required. Our plan has been to fully recover the cost of operations from admission and participation fees. We have no reason to believe that this will not occur.

Dr. FLETCHER. We will not spend NASA money for maintenance and operation related to the exposition.

Mr. TALCOTT. You have had some experience with huge crowds down there, watching space flight takeoffs. But I am not sure you have had enough experience with the great American public at a Bicentennial type of celebration, and that you are aware of all the extra maintenance and damage that is going to be caused to your property and facilities.

Dr. FLETCHER. Mr. Talcott, you have an awfully good point. We are restricting the attendance to certain locations at the Kennedy Space Center, primarily adjacent to the VAB—the vehicle assembly building—and the visitors information center, which is already pretty heavily attended. But as far as anticipating the kinds of crowds and what they may do in that particular area, we are venturing into uncertain territory.

But again, we will not spend NASA money for those operations and we will not let visitors into areas which are required for the Shuttle or other development work at KSC.

Mr. TALCOTT. Thank you.

KSC-TECHNICAL SERVICES

Mr. ROUSH. On page RPM 2–12, the summary for technical services at the top of the page indicates that your current estimate for fiscal year 1976 is $710,000 higher than you anticipated in the budget. Also, you are asking for an aditional $341,000 above that in fiscal year 1977. Would you tell us a little bit about what kind of problems you have encountered in fiscal year 1976 that were not anticipated in this area?

Mr. KLINE. The increases are in the area of ADP, and in our education and information programs. Support contract wage increases cause the increases within 1976 and in 1977.

KSC-ADMINISTRATIVE SUPPORT

Mr. ROUSH. On page RPM 2–15, the same kind of situation shows up for administrative support, up $884,000 above your 1976 estimate; another $1,538,000 above that in 1977. I note that in the original 1976 estimate, you indicated you were going to have nearly $1 million savings in this area. What has happened? What changed your 1976 budget so dramatically?

Mr. KLINE. The administrative support category has increased within 1976, due to rate increases in communications and a 12-percent price increase for administrative supplies, materials, and equipment from fiscal year 1976 to fiscal year 1977. On the other hand, we have tried to achieve additional economies in the transportation area, and we have made some reductions.

In fiscal year 1976, administrative support services shows an increase of $560,000. This is due to the beginning of the Shuttle buildup and the support effort that is required for this buildup at KSC.

Mr. ROUSH. What led you to this estimate that you were going to have nearly a $1 million savings in this area, which was made in your original fiscal year 1976 estimate?

Mr. KLINE. We were hopeful that the price increases would not turn out to be as high as they were. On reassessing those increases, and reassessing actual demands for printing, we were not able to hold to the forecasted level. We had to make those increases.

MARSHALL SPACE FLIGHT CENTER (MSFC)

Mr. ROUSH. OK.

Turn to page RPM 3–1, the Marshall Space Flight Center. On RPM 3–4, the total direct positions for fiscal year 1975 is 3,292. The budget estimate for 1976 indicates an increased estimate of 18 direct positions. What was that increase for, and from where are you taking the 1977 reduction of 88 positions?

MSFC CIVIL SERVICE REDUCTION

Mr. KLINE. The increase from fiscal year 1975 to the current estimate—from 3292 to 3310—was in the area of space research and technology related to energy work. Practically all of it was in that area with a relatively minor increase in support of the applications effort.

Now, the reductions that are going to be taking place in fiscal year 1977 are based on the results of our institutional assessment relating to reduced involvement of the Marshall Space Flight Center in the ground operations activity in the area of Spacelab. Specifically, the Spacelab integration work is to be located at the Kennedy Space Center, and the flight operations for the Spacelab will be at the Johnson Space Center.

SPACELAB INTEGRATION WORK AT KSC

Mr. ROUSH. Why is that?

Mr. KLINE. It is based on economy considerations with the intent of making the ground operations as efficient as possible by reducing the number of locations the Spacelab would have to be moved in preparation for launch and to avoid the additional facility and manning buildings that would otherwise be required. The transportation considerations, we have found, make it the more economical thing to do. Perhaps Mr. Yardley would like to make a comment on that.

Mr. YARDLEY. That is basically correct. In order to take spacelabs through Marshall and then to Kennedy would require a total new facility and ground support at the Marshall Space Flight Center which would duplicate those at Kennedy. It was not cost-effective.

MSFC INDIRECT CIVIL SERVICE POSITIONS

Mr. ROUSH. Now, concerning indirect positions for the Director and staff, you had an increase in fiscal year 1976 from the original estimate. Now you are showing a substantial decrease. What were those positions and what were increased and decreased?

Mr. KLINE. I could not tell you specifically what the three positions were in going from 136 to 139. There was a management decision to move some of the resources management positions from one of the

other offices to the Director's staff. That accounts for the 136 to the 144.

The reductions which you referred to are part of the overall indirect position reduction at the Marshall Center, related to the direct program reductions direct manpower reductions at the Center.

MSFC UTILITIES COSTS

Mr. ROUSH. On page RPM 3–12, under "Utilities," why did you estimate a reduction for utility costs in 1976 of $406,000? You did not anticipate that rates were going down, I would have to assume?

NASA-WIDE ENEGRY CONSERVATION EFFORTS

Mr. KLINE. No, sir.

There is a substantial effort underway at the Marshall Center to reduce the consumption of energy. This is not only occurring at Marshall; it is an agencywide program which Dr. Low inaugurated. That reduction anticipated the specific efforts at the Marshall Center.

Mr. ROUSH. Then your current estimate goes up considerably.

Mr. KLINE. Yes, it does.

Mr. ROUSH. What happened to the effort?

Mr. KLINE. At the Marshall Center, there was a 33-percent rate increase in the actual charges for utilities at the Center. Going from fiscal year 1976 to 1977, there will be an additional 19-percent rate increase.

Dr. LOW. Mr. Chairman, we just cannot hold own own. We have cut back 24 or 25 percent on the use of utilities, but the bills keep going up and up, and there is just no way of keeping up with it.

Mr. ROUSH. My next question was: In measuring your actual usage, did your program pay off? Did you actually reduce the usage?

Dr. LOW. Yes. From fiscal year 1973 till now we have reduced by 24 or 25 percent. We have additional plans, through utility management systems, which will bring this down to, we believe, 33 percent by 1977 and 50 percent by 1985.

General CURTIN. May I expand on that?

From fiscal year 1973, the cost to NASA per million BTU's was on the order of $1.76. I may have the precise figure. We are looking at figures now of $4.10 at the end of fiscal year 1976 for the same amount of energy. It is that unit cost of energy that is a terrific factor.

As Dr. Low points out we have a 25-percent reduction below 1973 at the end of the first half of this fiscal year. We are aiming toward a 30-percent reduction by the end of fiscal year 1977.

NASA ENERGY MANAGEMENT MULTIYEAR ACTION PLAN

Mr. ROUSH. It is easy to believe you, because I think all of us write a check once a month for utilities. I have observed it in my own personal account.

Dr. LOW. We have a firm plan, Mr. Chairman, of how to get down further, and I would like to submit to the committee, if I may. It outlines how NASA plans to reduce total utility usage, not cost, 50 percent by 1985 and is called NASA energy management multiyear action plan.

Mr. ROUSH. We will receive that. It might be useful for other agencies, also.

[The information follows:]

NASA
National Aeronautics and Space Administration

ENERGY MANAGEMENT MULTIYEAR ACTION PLAN

BACKGROUND

SITUATION:

- NATIONAL INABILITY TO PRODUCE ENOUGH PETROLEUM
- DECREASING RESERVES OF NATURAL GAS
- GREATER RELIANCE ON FOREIGN OIL SOURCES
- TOP MANAGEMENT MANDATES IMPROVED ENERGY UTILIZATION

RESULTS:

- INCREASED VULNERABILITY TO SUPPLY DISRUPTIONS
- THREAT TO NATIONAL ECONOMIC VIABILITY
- RAPID RISE OF ENERGY COSTS
- SHORTAGE/CURTAILMENTS OF SOME ENERGY RESOURCES
- NASA ACHIEVES LEADERSHIP IN FEDERAL ENERGY MANAGEMENT PROGRAM (22% REDUCTION)

ACTIONS:

- MORE INNOVATIVE AND AGGRESSIVE ENERGY MANAGEMENT PROGRAMS
- CONSERVATION OF PRESENT RESOURCES
- BUDGETARY PRIORITIES FOR ENERGY MANAGEMENT
- APPLICATION OF ALTERNATE ENERGY SOURCES TO FACILITY NEEDS

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NASA
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ENERGY MANAGEMENT MULTIYEAR ACTION PLAN

ACTIVITIES TO DATE

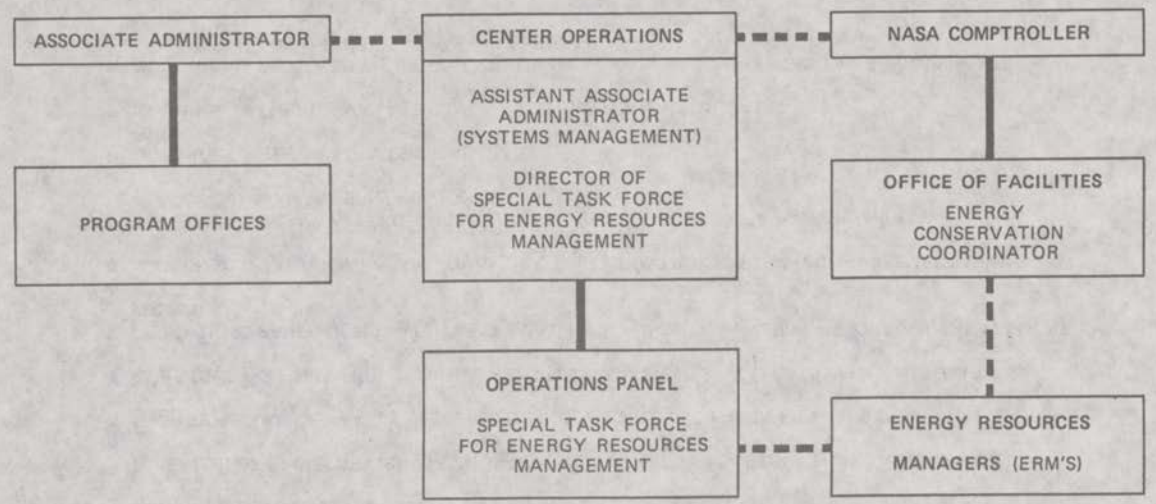
- ACHIEVED 22% REDUCTION BELOW FY 1973 ACTUAL CONSUMPTION
- DIRECTOR OF FACILITIES (BX) DESIGNATED "NASA ENERGY CONSERVATION COORDINATOR"
- ENERGY RESOURCES MANAGERS (ERM) DESIGNATED AT EACH NASA FIELD INSTALLATION
- QUARTERLY ENERGY PERFORMANCE REPORTS FROM FIELD INSTALLATIONS SUBMITTED TO BX
- OPERATIONS PANEL DESIGNATED AS SPECIAL TASK FORCE FOR ENERGY RESOURCES MANAGEMENT POLICY
- MAY 1975: MANAGEMENT APPROVAL OF UTILITY CONTROL SYSTEM (UCS) IMPLEMENTATION
- SEP 1975: NASA FY 1977 CoF PROGRAM INCLUDES FIRST INCREMENT FOR ENERGY MANAGEMENT PROJECTS
- OCT 1975: REVISED GOALS ESTABLISHED
- NOV 1975: ENERGY MANAGEMENT MULTIYEAR PLAN FORMULATED
- NOV 1975: PROPOSED FY 1978 CoF PROGRAM AS MAJOR FOCUS ON CAPITAL IMPROVEMENTS TO ENHANCE ENERGY CONSERVATION

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12-15-75

NASA
National Aeronautics and Space Administration

ENERGY MANAGEMENT MULTIYEAR ACTION PLAN

MANAGEMENT CHART



DIRECT SUPPORT

INDICATES COORDINATION

- Review/Recommend Policies and Guidelines
- Review/Recommend Goals and Initiatives
- Coordinate Multi-Year Action Plan
- Evaluate Proposed Modifications to Existing Operational Procedures – Coordinate with Program Offices and Field Installations
- Provide Focal Point for Continuous Coordination and Review with BX

- Establish Goals and Initiatives
- Focal Point for Energy Resources Managers (ERM)
- Project Management
- Fund Special Studies
- Quarterly Energy Performance Reporting
- Recommend C of F Budgetary Support

NASA HQ 8X76-1512(1)
12-15-75

NASA
National Aeronautics and Space Administration

ENERGY MANAGEMENT MULTIYEAR ACTION PLAN

GOALS

FISCAL YEAR	CUMULATIVE % REDUCTION FROM BASE YEAR	
1973	BASE YEAR	
1974	16	ACHIEVED
1975	22	ACHIEVED
1976	27	PROGRAMMED* NEAR-TERM
1977	30	PROGRAMMED* NEAR-TERM
1980	40	POTENTIAL* LONG-TERM TARGETS
1985	50	POTENTIAL* LONG-TERM TARGETS

*Target Development Sources:

- Proposed Energy Legislation to Reduce Federal Government Consumption
- Federal Energy Management Program, FEA, Multi-Year Action Plan Initiatives for New and Existing Buildings
- GSA "Energy Conservation Guidelines for New and Existing Office Buildings"
- Preliminary Findings and Demonstrations of Pilot Programs

NASA HQ 8X76-1513 (5)
12-15-75

NASA
National Aeronautics and Space Administration

ENERGY MANAGEMENT MULTIYEAR ACTION PLAN

MAJOR INITIATIVES — ESTIMATED RESULTS

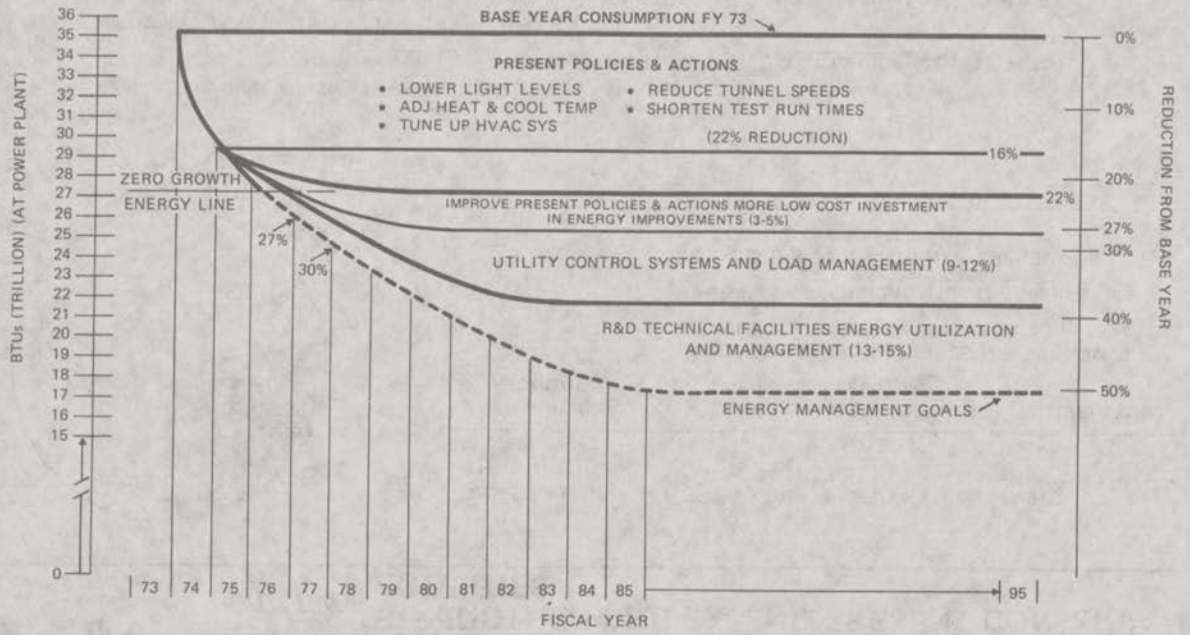
INITIATIVE		ESTIMATED RESULTS COST AVOIDANCE*	ENERGY SAVINGS BILLIONS OF BTU	% REDUCTION FROM 1973
• STRENGTHEN AND EXTEND PRESENT CONSERVATION ACTIVITIES	(ACHIEVED)	$19 M (TO DATE)	7,460	22%
	(ESTIMATED)	$4 M/YR.	1,000	3-5% ADDITIONAL
• INSTITUTIONAL LOAD MANAGEMENT AND CONTROL	(ESTIMATED)	$13 M/YR.	3,400	9-12% ADDITIONAL
• IMPROVED TECHNICAL FACILITIES ENERGY UTILIZATION	(ESTIMATED)	$19 M/YR.	5,100	13-15% ADDITIONAL
	TOTAL POTENTIAL	$55 M/YR.*	16,960	50%

*Based on Actual Savings to Date and FY 1976 First Quarter Energy Costs ($3.75/Million BTU's).

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ENERGY MANAGEMENT MULTI-YEAR ACTION PLAN

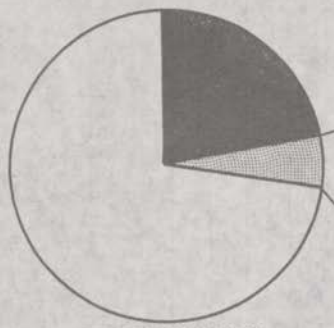


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NASA
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ENERGY MANAGEMENT MULTIYEAR ACTION PLAN

INITIATIVE: STRENGTHEN AND EXTEND PRESENT CONSERVATION ACTIVITIES



FY 1973 UTILITIES CONSUMPTION

22% REDUCTION

- MAINTAIN PRESENT ENERGY LEVELS AND ACTIVITIES

3-5% ADDITIONAL REDUCTION

- IMPROVE AND STRENGTHEN EFFECTIVENESS OF ENERGY CONSERVATION
- INCREASE LOW COST INVESTMENTS FROM ALL SOURCES IN ENERGY CONSERVATION
- IMPROVE TECHNICAL FACILITY OPERATIONS
- CONSIDER ALLOCATION OF ENERGY FOR TECHNICAL FACILITIES

PRESENT ACHIEVEMENTS (22% REDUCTION)

ENERGY SAVINGS: 7,460 (BILLION) BTU'S COST AVOIDANCE: $19 M TO DATE

ANTICIPATED RESULTS (3-5% ADDITIONAL REDUCTION)

COST: $3-5 M ENERGY SAVINGS: 1,000 (BILLION) BTU'S COST AVOIDANCE: $4 M/YR.

*Based on FY 1976 first quarter actual cost

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ENERGY MANAGEMENT MULTIYEAR ACTION PLAN

INITIATIVE: STRENGTHEN & EXTEND PRESENT CONSERVATION ACTIVITIES (CONTINUED)

IMPLEMENTATION ACTIONS:

- CONTINUE IMPLEMENTATION OF ILLUMINATION POLICY
- FURTHER ADJUSTMENT OF HEATING AND COOLING TEMPERATURES
- FURTHER "TUNE-UP" OF MECHANICAL SYSTEMS
- REDUCTION IN TECHNICAL FACILITIES "RUN" TIMES
- CONSIDER INITIATING ENERGY ALLOCATIONS BY FUNCTION
- "QUICK-RETURN" CAPITAL INVESTMENT, WITHIN FIELD INSTALLATION APPROVAL LIMITS, IN ENERGY SAVINGS IMPROVEMENTS
- REDUCE VEHICLE AND AIRCRAFT ENERGY CONSUMPTION

SCHEDULE:

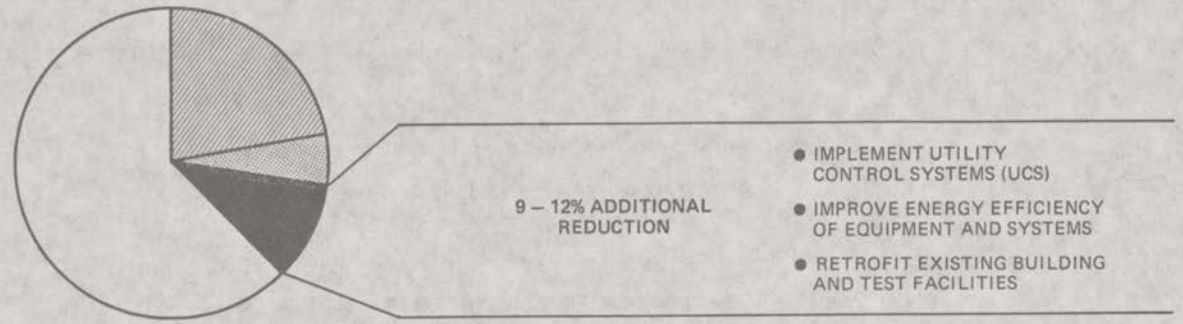
- IMMEDIATE ACTION REQUIRED, FY 1976, TRANSITION PERIOD, FY 1977

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ENERGY MANAGEMENT MULTIYEAR ACTION PLAN

INITIATIVE: INSTITUTIONAL LOAD MANAGEMENT AND CONTROL



ESTIMATED RESULTS:

COSTS	(ALREADY PROGRAMMED)	:	$5 M	ENERGY SAVINGS	: 3,400 (BILLION) BTU'S
	(ADDITIONAL REQUIRED)	:	21 M	COST AVOIDANCE:*	: $13M/YR
	SOFTWARE UCS COSTS (NOT INCLUDED ABOVE)	:	9 M		

* Based on FY 1976 first quarter actual cost.

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ENERGY MANAGEMENT MULTIYEAR ACTION PLAN

INITIATIVE: INSTITUTIONAL LOAD MANAGEMENT AND CONTROL (CONTINUED)

IMPLEMENTATION ACTIONS:

- UTILITIES ENERGY MANAGEMENT STUDIES
- INFRARED SCANNING AND RESULTANT REHAB
- ENERGY IMPACT ASSESSMENTS
- BUILDING ENERGY ANALYSIS AND MANAGEMENT (BEAM) COMPUTER MODELING
- UCS (OPTIMIZE ENERGY SYSTEMS)
- RETROFIT EXISTING BUILDING SHELLS AND TEST FACILITIES
- MODIFICATION OF EXISTING HVAC SYSTEMS
- IMPROVE BOILER PLANT EFFICIENCY (H_2O/OIL EMULSIFICATION)
- REVISE FACILITIES ENGINEERING STANDARDS
- IMPROVE SPACE UTILIZATION
- SMALLER HVAC FOR OFF-SHIFT, LOW VOLUME USES
- CLOSE MARGINAL USEAGE IDLE AND/OR REDUNDANT FACILITIES
- REFUSE-FIRED ENERGY SYSTEMS
- WASTE HEAT RECOVERY SYSTEMS
- APPLY ALTERNATE ENERGY SOURCES TO FACILITIES (SOLAR, FUEL CELLS, WIND, ETC.)

SCHEDULE:

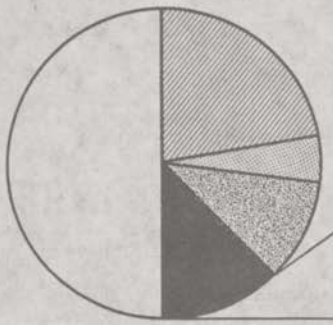
FY 1976 AND FY 1977 - STUDIES; FY 1977, FY 1978, FY 1979, AND FY 1980 - CoF PROJECTS

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ENERGY MANAGEMENT MULTIYEAR ACTION PLAN

INITIATIVE: IMPROVED TECHNICAL FACILITIES ENERGY UTILIZATION



FY 1973 UTILITIES CONSUMPTION

13-15% ADDITIONAL REDUCTION

- IMPROVEMENTS IN OPERATION OF TECHNICAL FACILITIES
- REHABILITATION AND MODIFICATION OF ENERGY INEFFICIENT TECHNICAL FACILITIES (CAPITAL IMPROVEMENTS)

ESTIMATED RESULTS:

COST (ROUGH ESTIMATE): $40 M

COST AVOIDANCE:* $19 M/YR.

ENERGY SAVINGS: 5,100 (BILLION) BTU

*Based on Fy 1976 first quarter actual costs.

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ENERGY MANAGEMENT MULTIYEAR ACTION PLAN

INITIATIVE: IMPROVED TECHNICAL FACILITIES ENERGY UTILIZATION (CONTINUED)

IMPLEMENTATION ACTIONS:

- TECHNICAL FACILITIES ENERGY UTILIZATION STUDIES
- AUTOMATIC WIND TUNNEL MODEL POSITIONING AND MODEL CHANGEOVER (REDUCE RUN TIMES)*
- UTILITY CONTROL SYSTEM (UCS) TYPE APPLICATION TO R&D OPERATIONS
- LOGIC SCHEDULING OF TECHNICAL OPERATIONS (REDUCE NUMBER OF RUNS AND RUN TIMES)*
- IMPROVE COMPUTERIZED MONITORING AND DISPLAY OF TEST DATA
- STANDARDIZE EXPERIMENT PACKAGING TO IMPROVE TEST RESULTS
- IMPROVE EFFICIENCY OF R&D STEAM PRODUCTION AND USAGE
- RECOVERY AND UTILIZATION OF WASTE HEAT FROM TEST FACILITIES
- CONSERVE AND LIMIT USE OF R&D PRESSURANTS AND PROPELLANTS
- IMPROVE INSTRUMENTATION AND DATA ACQUISITION
- INCREASE WIND TUNNEL FLOW EFFICIENCY
- FURTHER APPLICATION OF COMPUTER SIMULATION TO REDUCE OPERATION OF TECHNICAL FACILITIES

SCHEDULE:

FY 1976 AND FY 1977 - STUDIES; FY 1978, FY 1979 AND FY 1980 - CoF PROJECTS

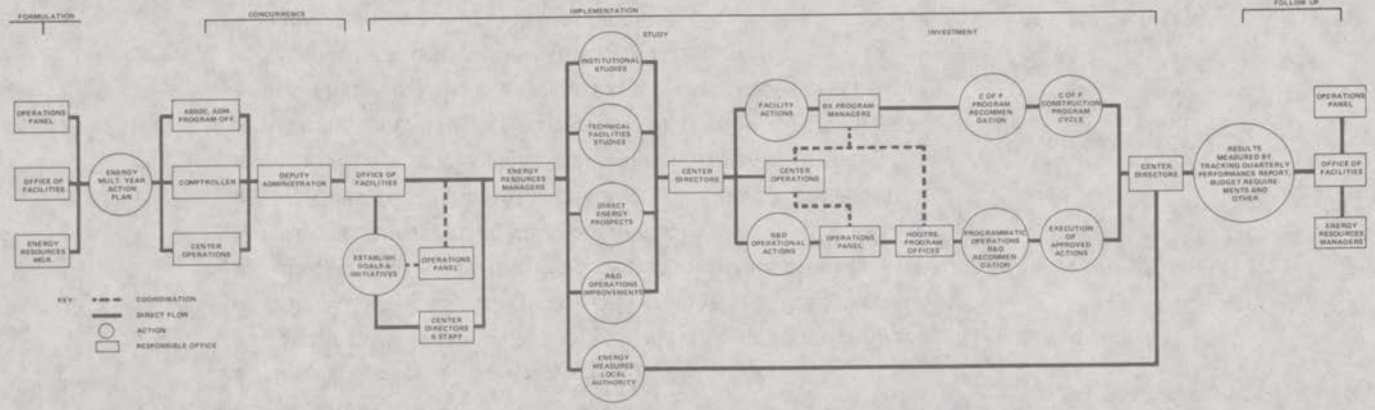
* (Reduce run times) should result in increasing idle test facility periods with same productivity.

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ENERGY MANAGEMENT MULTIYEAR ACTION PLAN

ACTION PLAN FLOW CHART



14

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ENERGY MANAGEMENT MULTIYEAR ACTION PLAN

CONCLUSIONS

- CONSERVATION MEASURES TO DATE HAVE REDUCED NASA'S ENERGY CONSUMPTION BY 1.3 MILLION BARRELS OF OIL EQUIVALENT PER YEAR (22%) BELOW FY 1973 CONSUMPTION LEVEL. RESULTANT COST AVOIDANCE TO DATE FOR FISCAL YEARS 1974 AND 1975 - $19 M.
- STRENGTHENING AND EXTENDING PRESENT CONSERVATION ACTIVITIES WILL PRODUCE ADDITIONAL 3-5% REDUCTION BELOW FY 1973 CONSUMPTION
- MAJOR CAPITAL INVESTMENT IS REQUIRED TO FURTHER REDUCE ENERGY CONSUMPTION.
- RAPIDLY RISING ENERGY COSTS MAKES CAPITAL INVESTMENT A VERY COST EFFECTIVE CONSIDERATION.
- TECHNICAL FACILITY IMPROVEMENTS IN ENERGY USE MUST CONTRIBUTE TO SHORT AND LONG TERM GOALS/TARGETS.
- OFFICE OF FACILITIES AND CENTER FACILITIES STAFFS MUST IDENTIFY AND DEVELOP ENERGY MANAGEMENT PROJECTS FOCUSED TO FY 1978 CoF PROGRAM.
- NASA HAS THE CAPABILITY TO UNDERTAKE ENERGY CONSERVATION PROGRAMS.

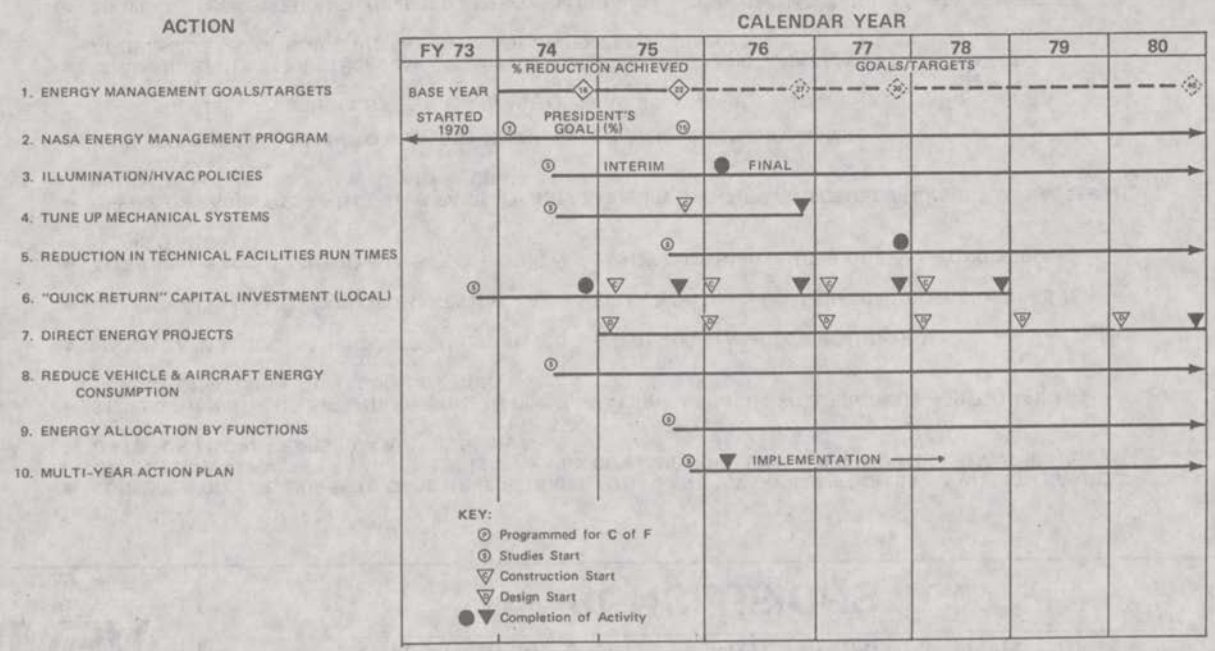
  SUCCESS CAN ENHANCE THE NASA IMAGE OF LEADERSHIP IN BOTH GOVERNMENT AND INDUSTRY.
- TOP MANAGEMENT MUST INCREASE COMMITMENT OF RESOURCES AND MAINTAIN ENTHUSIASM FOR AGGRESSIVE AND INNOVATIVE ENERGY MANAGEMENT PROGRAMS.
- PROPERLY CONCEIVED AND JUSTIFIED ENERGY PROGRAMS MUST BE GIVEN SPECIAL BUDGET PRIORITIES.

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ENERGY MANAGEMENT MULTIYEAR ACTION PLAN

STRENGTHEN AND EXTEND PRESENT CONSERVATION ACTIVITIES



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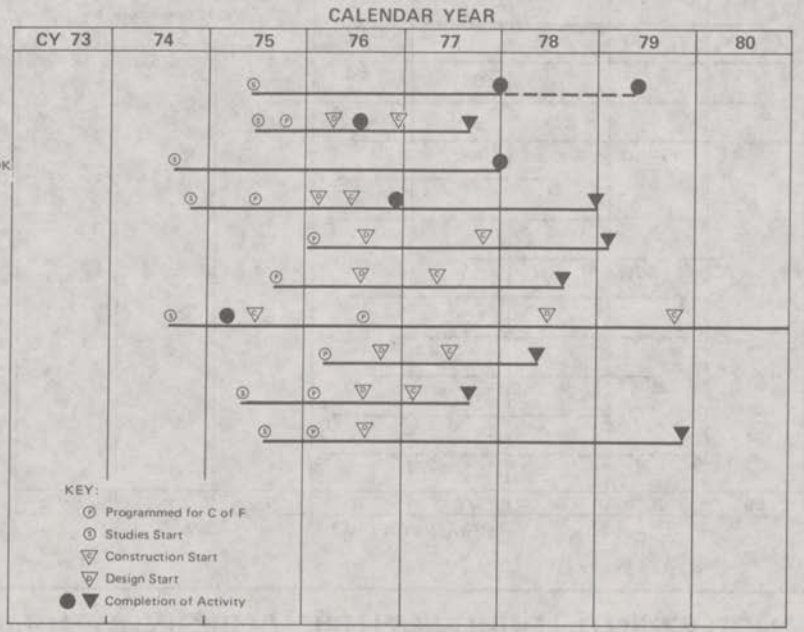
NASA
National Aeronautics and Space Administration

ENERGY MANAGEMENT MULTIYEAR ACTION PLAN

INSTITUTIONAL LOAD MANAGEMENT

ACTION

1. UTILITIES ENERGY MANAGEMENT STUDIES
2. IR SCANS & REMEDIAL ACTIONS
3. COMPUTER MODELING (BEAM) & ENERGY HANDBOOK
4. UCS (OPTIMIZE ENERGY SYSTEMS)
5. WASTE HEAT RECOVERY PROGRAM
6. REFUSE FIRED ENERGY SYSTEMS
7. ALTERNATE ENERGY SOURCE APPLICATION
8. RETROFIT BUILDINGS & TEST FACILITIES
9. IMPROVE BOILER PLANT EFFICIENCY
10. MISCELLANEOUS (ENERGY IMPACT ASSESSMENT, HVAC SYSTEM MODS, FACILITY ENGINEERING STDS REVISION, IMPROVE SPACE UTILIZATION, ETC.)

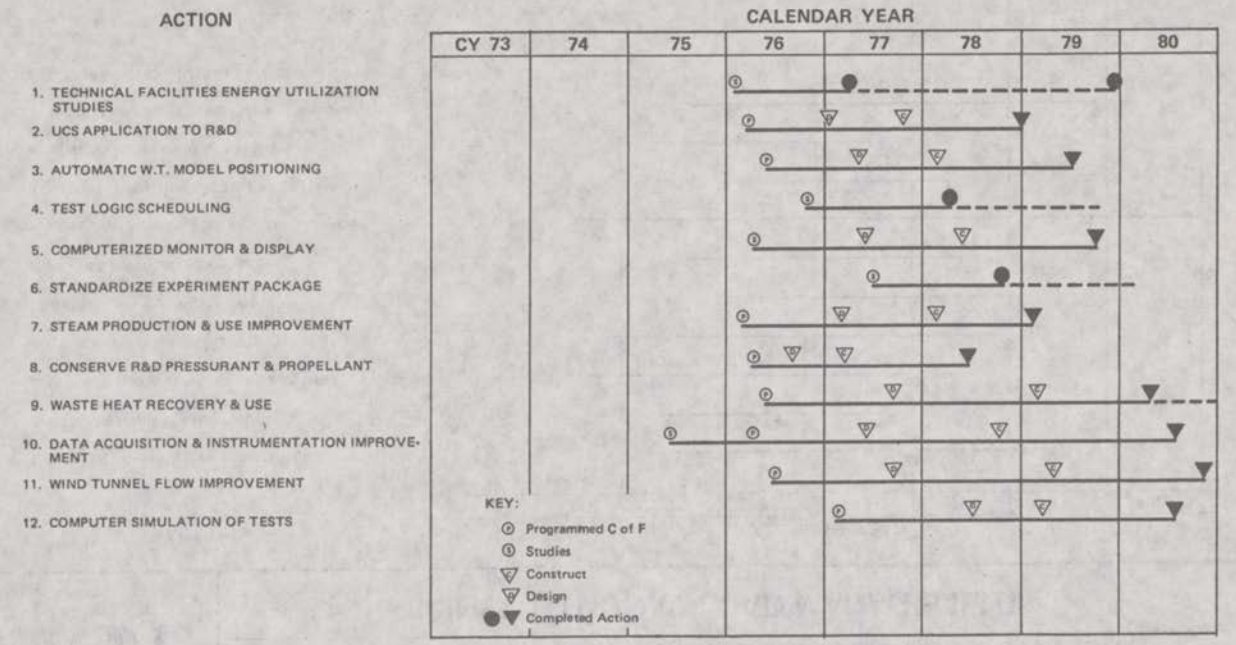


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ENERGY MANAGEMENT MULTIYEAR ACTION PLAN

IMPROVE TECHNICAL FACILITIES ENERGY UTILIZATION

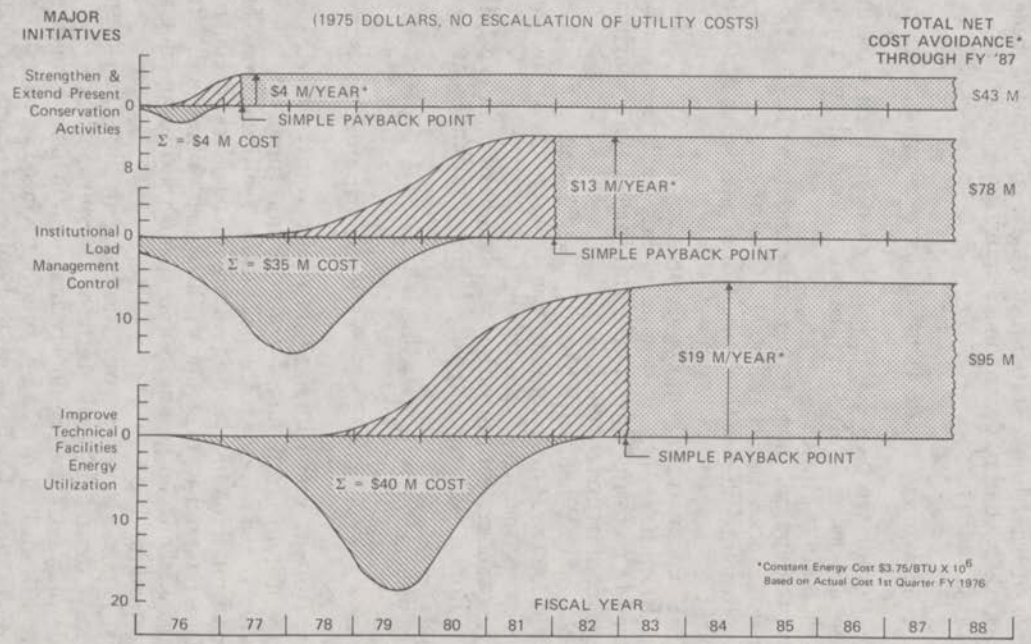


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ENERGY MANAGEMENT MULTIYEAR ACTION PLAN

COST/PAYBACK SCHEDULE



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MSFC ADMINISTRATIVE SUPPORT

Mr. ROUSH. Under "Administrative support" on page RPM 3–15, why do you need an increase of $166,000 in fiscal year 1977, when MSFC is planning a substantial decrease in total personnel?

Mr. KLINE. In fiscal year 1977 we have to cover the inflation along the lines of what I have stated previously. In addition, because of fund constraints we had to defer some acquisition of supplies and materials to fiscal year 1977.

NATIONAL SPACE TECHNOLOGY LABORATORIES (NSTL)

Mr. ROUSH. On page RPM 4–1, the national space technology laboratories are described. NSTL is responsible for the testing of the Space Shuttle main engines.

Do I understand those tests are now underway?

Dr. FLETCHER. Yes, they are, Mr. Chairman.

Mr. ROUSH. What is the longest duration firing of the main engine to date?

Mr. YARDLEY. It is about 3½ seconds.

Dr. FLETCHER. Mr. Chairman, in these early test periods, it is not planned to go to full duration or full thrust. We are primarily testing the engine startup sequence.

Mr. ROUSH. When will we see firings of longer duration?

Mr. YARDLEY. Our plan is to reach 60 seconds by the end of March.

Dr. FLETCHER. And full duration?

Mr. YARDLEY. Full duration will be later on, in the fall.

Mr. ROUSH. When we speak of full duration, what we are talking about?

Mr. YARDLEY. About 600 seconds.

STATUS OF NAVY OCEANOGRAPHIC MOVE TO NSTL

Mr. ROUSH. You will recall last year you requested the committee to OK a reprograming of construction funds for the anticipated transfer of the Navy's oceanographic facilities from Maryland to Mississippi. This has been involved in considerable controversy here. As I understand it, it is now in the courts. What is the status of that situation? Did you go ahead and spend the full amount requested in the reprograming?

Mr. LILLY. Let me answer the last part first, and then I will ask General Curtin to give the status of the court action.

The plan that we previously had would have, over time, incurred about $1.8 million of NASA funding related to this move. As of the first of January, I believe, we had obligated about $1,206,000. The actual expenditures against that were approximately $800,000.

As to the status of the actions taken by the court, I believe General Curtin is more up-to-date on that than I am.

General CURTIN. As a result of the temporary injunction placed by the court, we ceased all facility work at NSTL as of the 31st of December. A modification to the injunction, however, permitted us to go ahead with the work on building 902 at the Slidell Computer Center necessary to move the Environmental Research Laboratory people from NSTL, since that was an internal NASA move. That work has proceeded, and has been completed.

At the moment, however, all work at NSTL is in a standdown mode. On the court action, as we understand it, the Secretary of Defense will make a personal judgment on this matter, as required by the court, around the first of April.

Following that judgment, it is the intent of the court to allow about 15 days for a response from the people involved in the litigation. We expect that there will be a further hearing by the court involving presentations by both sides around the first of May. That is the best forecast we have at the moment, Mr. Chairman.

AMES RESEARCH CENTER

Mr. ROUSH. If there are no questions on Goddard or Wallops, we will turn to page RPM 7–1 and the Ames Research Center.

AMES TRAVEL COSTS

On page RPM 7–8, "Travel," we note that your estimate of travel costs increased in both fiscal year 1976 and the transition quarter combined by about $376,000.

Why exactly has travel escalated at Ames so dramatically? Is there a reason for that?

Mr. KLINE. Yes, sir.

The Ames Research Center has been involved in some programs that require travel by a number of scientific and engineering personnel to distant places for, sometimes, relatively extended periods of time. Specifically, it is the stratospheric sampling missions to the Arctic, out to the Pacific, and to Central America.

This was one of the very few places where we had to make an upward adjustment in travel.

Mr. ROUSH. And this is something that could not have been anticipated?

Dr. FLETCHER. No, Mr. Chairman, this was part of the stratospheric research program, which we discussed earlier, where the Congress last year directed NASA to assume specific responsibilities for upper atmospheric research, technology, and monitoring. We did not anticipate it when we were last before you.

Mr. LILLY. A specific part of that increase—that is not unique to Ames, of course—was the per diem increase that occurred after our budget submission. The appropriate general provisions did allow an increase not to exceed 10 percent in travel limitations. We are not coming close to that limitation for the Agency in fiscal year 1976.

Dr. FLETCHER. Mr. Chairman, Mr. Groo has just arrived. He is the Associate Administrator for Center Operations, and he had another hearing this morning.

AMES UTILITIES COSTS

Mr. ROUSH. You have been very ably represented.

On page RPM 7–11, under "Utilities," I note that the current estimate for fiscal year 1976 is $650,000 less than your original estimate. What is the reason for that? Just a matter of not using the wind tunnels as much?

Mr. KLINE. It was a decrease in consumption, yes, sir.

AMES PERMANENT CIVIL SERVICE POSITIONS

Mr. ROUSH. Let us go back for a moment to page RPM 7–3 where the permanent positions are identified for Ames.

AERONAUTICS PERSONNEL

The Ames Center will lose 63 positions as their part of the Agency's total 500-position civil service reduction. Are any of these positions being taken from aeronautics work?

Mr. GROO. Yes, sir. There is some work being phased out, and some 23 positions engaged in aeronautics work have been phased out as specific efforts have been completed.

Dr. FLETCHER. Mr. Chairman, we do not actually tell the center directors in which areas they have to take the cuts. Mr. Groo is estimating that this is about how much they will take in the way of aeronautic cuts.

NASA-WIDE REDUCTION IN AERONAUTICS CIVIL SERVICE PERSONNEL

Mr. ROUSH. Will there be a net reduction in the number of positions for aeronautics work, across the board?

Mr. KLINE. Yes, sir. Around 42, agencywide.

Mr. GROO. As Dr. Fletcher said, we assessed the workload, and that is the basis on which we arrived at the manpower reductions. In working with the program offices there are some 40 fewer positions planned in aeronautics work for fiscal year 1977.

I think that there could be changes as we renegotiate funding requirements with the centers for fiscal 1977 or fiscal 1978.

LANGLEY PERMANENT CIVIL SERVICE POSITIONS

Mr. ROUSH. OK.

Let us turn to the Langley Research Center and look at the chart on page RPM 9–17, which describes the Center's positions in the various offices.

Of the 500 total civil service position reduction, Langley's is 158. It is clear from the chart that you are taking some of the positions out of the Office of Aeronautics and some of the offices associated with aeronautics work.

LANGLEY AERONAUTICS EFFORT

Now, we would again ask—I know this may be repetitive—but, while you are making these reductions, even though overall you may reduce only 42 out of about a 4,000-plus total, why, with so much emphasis being placed on aeronautics work, would you be reducing positions in this area?

Mr. GROO. Mr. Roush, actually our estimates are that there will be an increase on aeronautics work at Langley.

Mr. ROUSH. I thought the response a moment ago when I asked about the net was that there would be a decrease of 42.

Mr. GROO. At Langley, there will be a small increase related to our aircraft emergy efficiency technology efforts. Most of the reductions at Langley come out of lunar and planetary missions.

Mr. LILLY. The office of Aeronautics does not encompass all the aeronautics work at the Center. I believe there is a proposed increase in the total aeronautics effort of about 16 at Langley.

LANGLEY—GRADE LEVELS

Mr. ROUSH. In looking at the chart, we observe that in only two squares are any of the 158 positions taken from a GS–14 or above position. Why is that?

Dr. FLETCHER. Do you mean why do we not demote the people?

CIVIL SERVICE REDUCTIONS

Mr. ROUSH. No, I am not asking why not demote. But why is there not a comparable reduction of the higher level employees, as well as from the lower level employees?

Mr. GROO. There are reasons for it. One, I am not sure that it will not work out that way. We are basically hoping to take these reductions by attrition, if at all possible. If we are able take them by attrition, that will tend to reduce certainly, some of the higher grades, and we will have a reduction of the higher grades, because the attrition will come, among other things, from the retirement of people.

On the other hand, if we have to conduct a reduction in force, a RIF, that will tend to force out the younger people. Under attrition I would expect reductions to be pretty much across the board in all levels.

Mr. LILLY. Let me say this, Mr. Chairman, that when one is attempting to take reductions through attrition, it is strictly a guess, and we cannot be accurate about what grades would be affected.

The basic way we assess what the cost reduction will be, is on our experience of what has occurred in the past. Using this experience, we price out the average grade level costs that result from that level of attrition. We have used our best estimate on what the end result will be in these organizational charts.

RENTAL OF REAL PROPERTY

Mr. ROUSH. If there are no questions on the Lewis Research Center, we will turn to page RPM 11–1, "NASA Headquarters," and then continue to pages RPM 11–12 and look at "Rental of Real Property" where your budget estimate for fiscal year 1976 was $3,643,000 and the current estimate is $3,268,000.

As the justifications indicate, the reduction has to do with the 10-percent cut in GSA rental charges specified in the fiscal year 1976 Appropriations Act.

As you know, we placed this 10-percent cut across the board in all appropriations bills for both fiscal years 1975 and 1976.

Have you noticed any diminution in the service provided by GSA to NASA in the past 2 years?

Dr. FLETCHER. A simple answer to that is, "Yes."

Mr. ROUSH. In what regard?

Dr. FLETCHER. I can only speak for headquarters.

We have had problems with maintenance; we have had problems with maintaining security; problems with elevators. Generally speaking, service is adequate but not as good as it was.

I must say, I have a special complaint, and that is, in order to save money on custodial work, they schedule the custodial people in at certain times. If you have to work late, you have to work while they are cleaning. It makes it a little more difficult to get your work done.

Mr. ROUSH. Does your complaining do any good?

Dr. FLETCHER. We have complained, and we've told them about it, but we understand the pressure they are under.

Mr. GROO. We do talk with them, and we do urge them to improve their service, and I think they are trying to do that. They try to be responsive. I think they too, have problems.

Mr. ROUSH. I observed that GSA is back for an increase above the current estimate and the budget estimate. Would you care to comment on that?

Dr. FLETCHER. We have no idea what the reason for their increase is, so that would be hard to comment on, Mr. Chairman.

Mr. LILLY. I might comment that if it is to be applied to increased service in buildings which NASA occupies. I would fully support it.

Mr. ROUSH. I gather that what you have been telling us in that because of this, at least concurrent with the 10-percent cut across the board, you have noticed that service is not as good as it was?

Dr. FLETCHER. That is a fair statement, yes.

ADP SERVICES

Mr. ROUSH. On pages RPM 11–13 and 14, we see a substantial increase requested for ADP services.

The justifications indicate that the increase, principally, is to provide for the reconfiguration of the computer support for the NASA scientific and technical information programs.

Now, what does this mean?

Mr. GROO. We have had a continuing growth demand for services from the technical information organization. We have had to enlarge the computer capacity in order to be able to deal with the workload.

That group deals principally with the dissemination of scientific and technical information coming out of our R. & D. programs. As the information output grows, then the requirements on this organization grow commensurate by.

Mr. KLINE. These services are not just for headquarters, sir; it is for the entire Agency.

Mr. GROO. It is a headquarters function, but it is operated for the entire Agency.

COMPUTER LEASES OR UPGRADING

Mr. ROUSH. Are you leasing any new computers or upgrading your computer system?

Mr. GROO. We upgraded our headquarters computer system. Mr. Gray would know the answer as to whether we upgraded the STIO system.

Mr. GRAY. We did upgrade the STIO system.

Mr. ROUSH. And did you lease any new computers?

Mr. GROO. We replaced one old computer with a newer computer.

We also have incurred some increases in our support contractor wage rates.

Mr. ROUSH. When you say you had some increase, does that mean you are leasing more computers?

Mr. GROO. We leased in both our headquarters computer and in terms of STIO a larger computer, a larger capacity computer than we had before.

Dr. FLETCHER. The support contractors are the people that operate the computers.

HEADQUARTERS ADMINISTRATIVE SUPPORT

Mr. ROUSH. On page RPM 11–16, "Administrative Support" jumped almost $3½ million in fiscal year 1976 over your budget estimate.

How much did GSA increase the rates for local telephone service; and is that the principal reason for the large increase?

Mr. LILLY. I can give you the dollar amount of the increase. I would have to get the actual amount of rate increase in fiscal year 1976. There is an increase of about $172,000 on local telephones and about $9,000 on leased line and long distance.

We have provided in our budget for an increase of about $13,000 in local telephone costs from fiscal year 1976 to 1977, I believe.

Mr. ROUSH. OK. Now, what makes you think you can get the estimate for fiscal year 1977 back to $7,451,000?

Mr. GROO. For total administrative support?

Mr. ROUSH. Yes.

Mr. GROO. We had an extraordinary expenditure within our plan for 1976 which has not yet been made relating to administrative aircraft, which produces a bulge in 1976 and does not occur in 1977.

JET PROPULSION LAB

Mr. ROUSH. On page SA 4, under the Jet Propulsion Laboratory, I notice you had a substantial increase in man-years devoted to physics and astronomy and space applications from the original budget estimate in 1976.

Why is this?

INCREASE IN JPL FISCAL YEAR 1976 MAN-YEARS

Mr. MATTHEWS. The increase is largely related to the buildup of the SEASAT program, in the case of applications.

Mr. ROUSH. Why did the positions for lunar and planetary exploration drop from what you had last year?

Mr. GROO. We have fewer lunar and planetary activities planned in fiscal year 1977 for JPL than we had anticipated.

Mr. ROUSH. Would you like to identify it?

Mr. GROO. There were certain programs that were originally envisaged to be new starts, but did not come about because our budget was reduced. Therefore, we have not needed as many people in these areas.

Dr. FLETCHER. The main one we left out was the Mariner-Jupiter-Uranus mission.

Mr. ROUSH. Are there others?

Dr. FLETCHER. That was the main one.

There was the Jupiter Orbiter probe, but I don't believe that accounts for this decrease.

Dr. HINNERS. Most of that decrease relates to the Uranus mission.

NASA'S CONTRIBUTION TO THE NATION'S PROGRESS

Mr. ROUSH. Before turning the gavel over to Mr. Boland, Dr. Fletcher, I want to thank you and your people for being responsive to our questions and your willingness to respond forthrightly; that alone means quite a bit to us in this subcommittee.

We know you have a big job; we know you are operating under constraints that you, yourself, may not want, nor desire; but we also know that you have to do it.

We appreciate what you have contributed to the modern history of this country and, I think, the revitalization of a spirit in the country—that of exploration and accomplishing new things. I don't know of any agency in the Government which has done more to rekindle the American spirit than your own.

The committee is going to be also operating under many constraints as we view your budget, and we probably will be in communication with you between now and the time we are required to mark up our bill.

From my own personal standpoint, I want to thank you for being here and for being responsive.

Mr. Chairman?

Mr. BOLAND. As you know, this committee is operating within a time frame to get our recommendations to the floor at a very early date, with the result that we are spread awfully thin, particularly when you serve on two or three subcommittees.

I do appreciate very much the manner in which my colleague has handled these hearings, and he said it better than I. It is an area that he is terribly interested in, and I am delighted that he was able to conduct these hearings with NASA.

I want to underscore what he said with reference to NASA itself. I join with him in commending NASA and what it has done in the past and also its foresight in its projections for the future.

I might also say that of all the agencies that this committee deals with—and there are many—I don't believe any is more responsive or more knowledgeable with reference to their own activities than this agency is. At the same time, I want to commend the agency for its realization that we are operating under some budget constraints that affect all activities in the Government. NASA recognizes this and it accepts that responsibility, and I think you have done it in a very fine way.

I always marvel at the responses and the forthrightness with which this agency deals with the subcommittee. I am sure it deals the same way with the authorizing committees, too, and also our counterparts on the Senate side.

It does come here well prepared. NASA has an absolutely magnificent staff, under the direction of the Administrator, Jim Fletcher and the Deputy Administrator, George Low, who has been with NASA for some time. In my judgment, George Low is one of the most knowledgeable men in the Government service; and the same is true of Bill Lilly, who has been the NASA Comptroller for—how long?

Mr. LILLY. Let it remain as you said it, Mr. Chairman—a long time.

Mr. BOLAND. As long as I have been coming to this committee, and that goes back quite a few years, and we appreciate the thorough knowledge that you have on the budget of NASA.

It is a big budget; it is $3.7 billion; and it does require considerable knowledge on the part of all who are part of the NASA team.

And so, Dr. Fletcher, Dr. Low and Mr. Lilly, we very much appreciate your presence; and all of those who are engaged in the multitudinous activities with which NASA is engaged. Thank you very much for your appearance.

The committee stands adjourned.

JUSTIFICATION OF THE BUDGET ESTIMATES

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1977 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 programs:

-- 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 FY 1977 budget provides for continued progress toward the era of wide-spread participation in the exploration and use of space and of more efficient flight in the atmosphere. The budget provides for continued development of the Space Shuttle on a schedule consistent with an initial orbital flight in 1979, leading to an economical, versatile operational capability providing a wide variety of users with round-trip access to space in the 1980's. At the same time, the budget provides for continuing ongoing research and development and technology and initiating some significant new projects. Major ongoing projects which will continue in development in FY 1977 include the High Energy Astronomy Observatories, the Pioneer Venus missions, the Mariner missions to Jupiter and Saturn, LANDSAT-C, SEASAT, and TIROS-N, as well as science and applications explorers. In addition, work will be in progress on flight experiments which will take advantage of the unique capabilities of the Shuttle and Spacelab. The FY 1977 budget provides for initiation of the Solar Maximum Mission to study the Sun during its next period of peak activity; a magnetic field satellite, an applications explorer, to provide data useful for location of mineral resources; and a thematic mapper instrument to increase our future capability for detection and monitoring of earth resources.

In aeronautics, the budget provides for continuation of ongoing research activity and demonstration projects, and for a focussing of effort on developing the technology to permit the U.S. to produce in the 1980's aircraft capable of approximately twice the efficiency of current aircraft. The Budget also provides for initiation of construction of a National Transonic Facility, a specialized aeronautical facility which will have advanced capabilities to measure air-flow characteristics of aircraft operating near the speed of sound and will have wide applications as an R&D tool for development of future civilian and military aircraft essential for maintaining United States leadership in aeronautics.

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 $3,697,000,000 are requested for FY 1977 to support the program described in these justifications.

BUDGET SUMMARY

	FY 1975	FY 1976	Transition Quarter	FY 1977
		(Thousands of Dollars)		
BUDGET PLAN				
Research and development	2,323,563	2,677,380	700,600	2,758,925
Construction of facilities	142,655	82,130	10,750	124,020
Research and program management	764,704	795,498	220,795	814,055
TOTAL BUDGET PLAN	3,230,922	3,555,008	932,145	3,697,000
OUTLAYS	3,266,708	3,517,200	908,700	3,676,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET SUMMARY
(Thousands of Dollars)

Research and Development	Budget Plan FY 1975	FY 1976	Transition Quarter	FY 1977
SPACE FLIGHT	1,235,800	1,560,500	406,500	1,644,700
Space shuttle	797,500	1,206,000	321,000	1,288,100
Space flight operations	298,800	188,600	48,400	205,200
Expendable launch vehicles	139,500	165,900	37,100	151,400
SPACE SCIENCE	417,315	434,200	116,400	379,025
Physics and astronomy	136,315	159,300	43,500	165,800
Lunar and planetary exploration	261,200	254,100	67,700	191,100
Life sciences	19,800	20,800	5,200	22,125
APPLICATIONS	174,748	178,230	47,700	198,200
Space applications	174,748	178,230	47,700	198,200
AERONAUTICS AND SPACE TECHNOLOGY	237,765	250,250	63,100	271,100
Aeronautical research and technology	166,400	175,350	43,800	189,100
Space research and technology	71,365	74,900	19,300	82,000
ENERGY PROGRAMS	4,435	5,900	1,500	---
Energy technology applications	4,435	5,900	1,500	---
TRACKING AND DATA ACQUISITION	248,000	240,800	63,400	258,000
TECHNOLOGY UTILIZATION	5,500	7,500	2,000	7,900
TOTAL RESEARCH AND DEVELOPMENT	2,323,563	2,677,380	700,600	2,758,925
Construction of Facilities	142,655	82,130	10,750	124,020
Research and Program Management	764,704	795,498	220,795	814,055
TOTAL	3,230,922	3,555,008	932,145	3,697,000
OUTLAYS	3,266,708	3,517,200	908,700	3,676,000

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National Aeronautics and Space Administration

SPACE FLIGHT

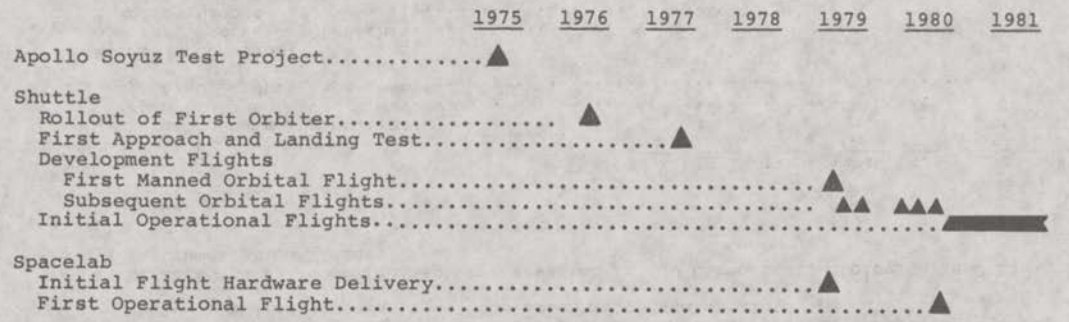
- Promote International Cooperation in Space

  --Spacelab Development by European Space Agency

- Develop Space Shuttle Transportation System

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

MAJOR FLIGHT ACTIVITY



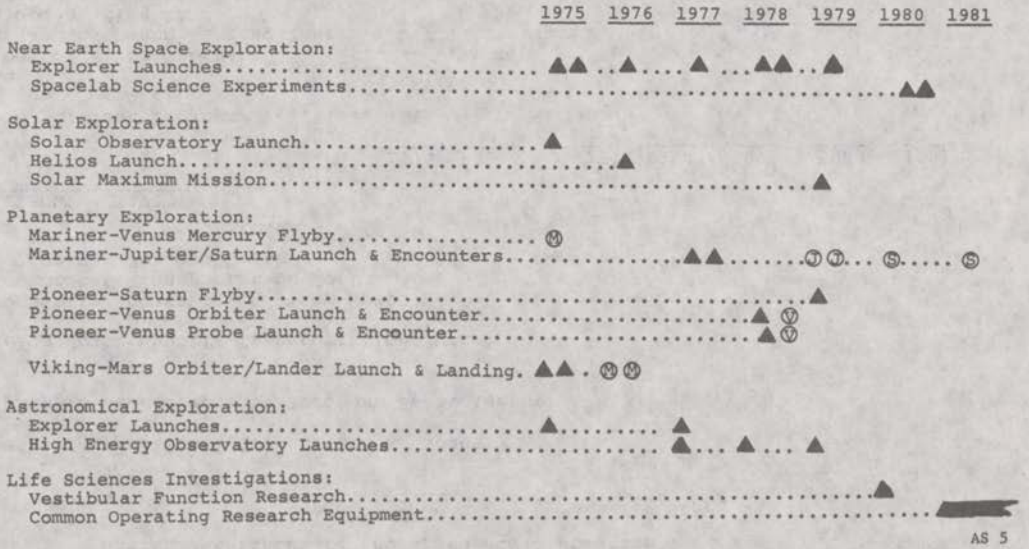
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National Aeronautics and Space Administration

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
- Utilize the space environment for research in the biomedical, biological and bio-instrumentation fields.

MAJOR FLIGHT ACTIVITY



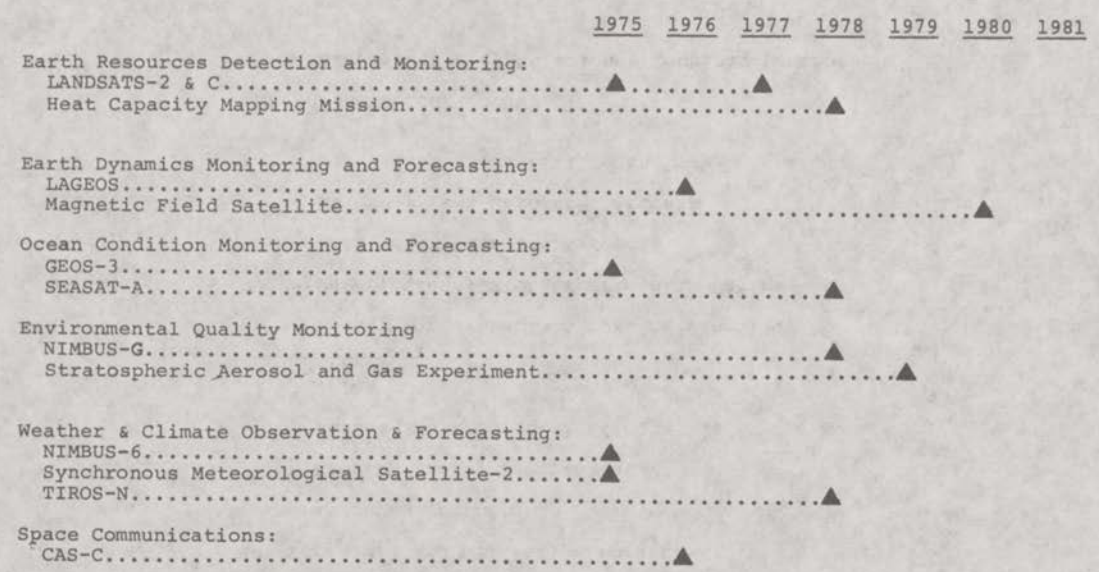
AS 5

National Aeronautics and Space Administration

SPACE APPLICATIONS

- Develop and demonstrate practical uses of space and space-derived 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

MAJOR TECHNOLOGY FOCUS

- --Aircraft Energy Efficiency Technology Efforts

National Aeronautics and Space Administration

SPACE 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 Power Systems

  --Low Cost Standardized Components

TECHNOLOGY UTILIZATION

- Accelerate the transfer of NASA-developed research and technology advances to public and private sectors.

National Aeronautics and Space Administration

ENERGY TECHNOLOGY APPLICATIONS

- Previous efforts focussed primarily on identification and refinement of NASA-developed technology holding greatest promise for contributions to solution of energy problems on Earth. No direct NASA R&D budget request for FY 1977.

- NASA will continue, on a reimbursable basis, to provide support to Federal, State, and local government agencies in implementing energy R&D programs.

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:

  --Automated Earth Orbiting Missions - Covers approximately 40 active satellites including NIMBUS-F, Geodynamic Experimental Ocean Satellite (GEOS) C, Landsat 1 and 2, Atmosphere Explorers (AE) C, D, and E, Orbiting Solar Observatory (OSO) I and the upcoming International Ultraviolet Explorer (IUE) and the High Energy Astronomy Observatory (HEAO) missions.

  --Planetary Missions - In addition to continuing support for several Pioneer spacecraft, Helios 1 and 2, Viking 1 and 2, and the MJS '77 will be covered.

  --Sounding Rockets

  --Research Aircraft

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1977 ESTIMATES

SUMMARY OF APPROPRIATIONS
(Thousands of dollars)

Appropriations	FY 1975 PL 93-414	FY 1976 PL 94-116	Transition Quarter PL 94-116	FY 1977 Request
Research and Development	2,331,015	2,677,380	700,600	2,758,925
Basic Appropriation	(2,326,580)	(2,677,380)	(700,600)	(2,758,925)
Special Energy Research and Development Appropriation Act, 1975 (PL 93-322)	(4,435)	---	---	---
Construction of Facilities	140,155	82,130	10,750	124,020
Research and Program Management	759,975	795,498	220,795	814,055
Basic Appropriation	(740,000)	(775,512)	(213,678)	(814,055)
Supplemental Appropriation for civilian pay raises (PL 94-32)	(19,975)	---	---	---
Proposed supplemental for civilian pay raises	---	(19,986)	(7,117)	---
Total	3,231,145	3,555,008	932,145	3,697,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1977 ESTIMATES

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

Fiscal Year 1975	Total	Research and Development	Construction of Facilities	Research and Program Management
Appropriation, PL 93-414	3,206,735	2,326,580	140,155	740,000
*PL 93-322	4,435	4,435	---	---
Supplemental Appropriation, PL 94-32	19,975	---	---	19,975
Subtotal	3,231,145	2,331,015	140,155	759,975
Transfers to other accounts: "Salaries and Expenses, General Management and Agency Operations," General Services Administration, 1975 (31 USC 581c)	-52	---	---	-52
Transfers between appropriations	---	-7,452	+2,500	+4,952
Unobligated balance lapsing	-171	---	---	-171
Total Budget Plan	3,230,922	2,323,563	142,655	764,704
Fiscal Year 1976				
Appropriation, PL 94-116	3,535,022	2,677,380	82,130	775,512
Proposed supplemental for civilian pay raises	19,986	---	---	19,986
Total Adjusted Appropriation (Budget Authority/Budget Plan)	3,555,008	2,677,380	82,130	795,498

*Special Energy Research and Development Appropriation Act, 1975.

Transition Quarter	Total	Research and Development	Construction of Facilities	Research and Program Management
Appropriation, PL 94-116	925,028	700,600	10,750	213,678
Proposed supplemental for civilian pay raises	7,117	---	---	7,117
Total Adjusted Appropriation (Budget Authority/Budget Plan)	932,145	700,600	10,750	220,795
Fiscal Year 1977				
Appropriation request/Budget Plan	3,697,000	2,758,925	124,020	814,055

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1977 AND TRANSITION QUARTER ESTIMATES

SUMMARY OF APPROPRIATION BUDGET PLANS BY INSTALLATION

(In millions of dollars)

Installation	Research and Development				Construction of Facilities				Research and Program Management				Total			
	1975	1976	Transition Quarter	1977	1975	1976	Transition Quarter	1977	1975	1976	Transition Quarter	1977	1975	1976	Transition Quarter	1977
Johnson Space Center	793.0	1,000.2	255.3	971.3	3.6	4.7	.3	5.0	121.3	128.2	36.2	134.3	917.9	1,133.1	291.8	1,110.6
John F. Kennedy Space Center, NASA	102.5	110.0	35.7	168.3	68.1	37.0	.4	42.9	95.9	97.4	30.5	103.6	266.5	244.4	66.6	314.8
Marshall Space Flight Center	290.9	415.0	109.8	465.7	11.7	1.4	.4	3.9	129.1	133.4	35.7	133.2	431.7	549.8	145.9	602.8
National Space Technology Laboratories	1.7	10.5	2.5	11.8	.1	.1	.2	.9	1.6	1.8	.4	1.8	3.4	12.4	3.1	14.5
Goddard Space Flight Center	384.2	361.2	94.4	403.0	4.4	1.3	.9	2.4	104.8	108.6	28.8	109.2	493.4	471.1	124.1	514.6
Wallops Flight Center	14.6	14.9	4.0	14.7	2.9	1.0	.1	1.7	12.4	13.1	3.6	13.7	29.9	29.0	7.7	30.1
Jet Propulsion Laboratory	173.7	189.3	51.5	177.9	11.3	1.8	1.2	2.3	---	---	---	---	185.0	191.1	52.7	180.2
Ames Research Center	116.3	140.3	32.9	115.3	5.5	4.8	.3	6.5	48.6	50.6	13.2	50.5	170.4	195.7	46.4	172.3
Flight Research Center	16.2	20.9	5.4	19.6	3.2	5.8	---	1.2	13.2	14.1	5.0	15.8	32.6	40.8	10.4	36.6
Langley Research Center	194.0	152.7	45.0	148.8	5.7	4.2	.9	33.9	88.6	92.9	24.3	91.7	288.3	249.8	70.2	274.4
Lewis Research Center	130.7	164.7	39.7	154.8	5.7	1.4	.6	3.7	80.3	81.7	22.6	85.7	216.7	247.8	62.9	244.2
NASA Headquarters	105.8	97.7	24.4	107.7	---	---	---	---	68.9	73.7	20.5	74.6	174.7	171.4	44.9	182.3
Construction of Facilities Programs																
Various Locations					7.5	---	---	---					7.5	---	---	---
Facility Planning and Design					10.9	9.3	2.5	12.6					10.9	9.3	2.5	12.6
Balance of the following programs undistributed by installation																
Space Shuttle Facilities					.8	3.0	---	1.8					.8	3.0	---	1.8
Rehabilitation and Modification					.2	3.8	2.7	3.4					.2	3.8	2.7	3.4
Minor Construction					1.1	2.5	.2	1.8					1.1	2.5	.2	1.8
Total Budget Plan	2,323.6	2,677.4	700.6	2,758.9	142.7	82.1	10.7	124.0	764.7	795.5	220.8	814.1	3,231.0	3,555.0	932.1	3,697.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

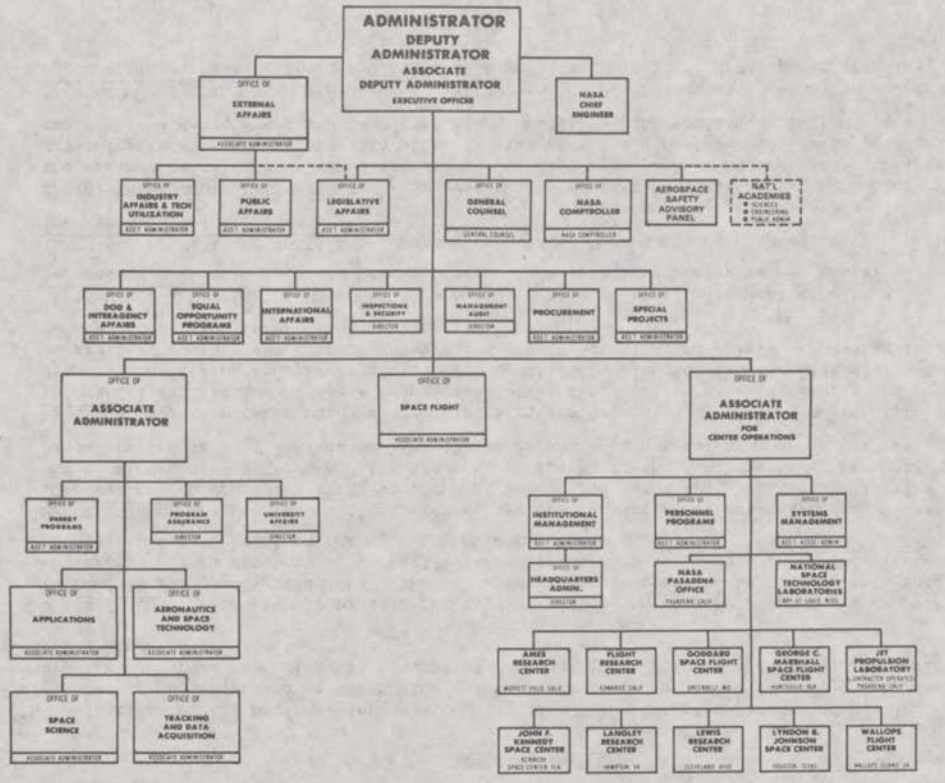
RESEARCH AND PROGRAM MANAGEMENT

TOTAL NUMBER OF PERMANENT POSITIONS

END OF YEAR

	FY 1975	FY 1976	Transition Quarter	FY 1977
Johnson Space Center	3,632	3,613	3,613	3,613
Kennedy Space Center	2,259	2,259	2,259	2,259
Marshall Space Flight Center	4,113	4,113	4,113	3,925
National Space Technology Laboratories	70	70	70	70
Goddard Space Flight Center	3,753	3,747	3,747	3,675
Wallops Flight Center	416	415	415	414
Ames Research Center	1,678	1,676	1,676	1,613
Flight Research Center	490	497	497	497
Langley Research Center	3,309	3,330	3,330	3,172
Lewis Research Center	3,025	3,025	3,025	3,025
Headquarters	1,571	1,571	1,571	1,553
Total, Permanent Positions	24,316	24,316	24,316	23,816

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1977 ESTIMATES

GENERAL STATEMENT

The objectives of the National Aeronautics and Space Administration program of research and development are to advance our knowledge of Earth, its space environment, and the universe, and to develop and utilize aeronautics and space technology to accomplish national goals. These objectives are achieved through the following elements:

SPACE FLIGHT: A program to provide the transportation and related support and capabilities required to conduct all space operations. The major development objective is the reusable Space Shuttle, the key element of an economical, versatile transportation system to provide a wide variety of users with round trip access to space during the 1980's and beyond.

SPACE SCIENCE: A program, utilizing space systems, supported by extensive ground-based and airborne observations, to conduct a broad spectrum of scientific investigations. The objective is to advance our knowledge of the Earth and its atmosphere, the Moon, the Sun, the inner and outer planets, interplanetary and interstellar space, and the other stars of our galaxy and the universe.

APPLICATIONS: A program using space, aircraft, and ground-based systems to identify and demonstrate the useful application of space techniques in the areas of resources detection and monitoring, earth dynamics monitoring and forecasting, ocean condition monitoring and forecasting, environmental quality monitoring, weather and climate observation and forecasting, materials processing in space, space communications and information management.

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

TRACKING AND DATA ACQUISITION: A worldwide program to support deep space, earth orbital, suborbital, and aeronautical programs.

ENERGY TECHNOLOGY APPLICATIONS: A program to assure that national energy technology programs receive the maximum benefit from NASA-developed aeronautics and space technology. Emphasis is now placed on providing reimbursable support to other Federal agencies and state and local governments engaged in research and development programs that are aimed at meeting national energy needs.

TECHNOLOGY UTILIZATION: A program to accelerate the dissemination to both the public and the private sectors of advances achieved in NASA's research, technology and development programs.

SPACE FLIGHT

Space Flight activities provide all the transportation and associated support and capabilities required to conduct space operations. These activities currently focus on the development of the Space Shuttle -- the first reusable space vehicle, and the key element of an economical, versatile Space Transportation System to provide domestic and international users with round trip access to space for the 1980's and beyond.

A major highlight of the 1975 program was the successful completion last July of the joint US/USSR Apollo Soyuz Test Project mission -- the first manned international space flight. This mission marked the end of the pioneering and productive Apollo era of manned space flight. The forward thrust of Space Flight Operations activities now focusses on an orderly transition to the Space Transportation System/Shuttle era, which will greatly increase the opportunities for wide-spread participation in the exploration and use of space.

During FY 1977, the development of the Space Shuttle and the development activities related to the establishment of the space transportation system operations capability will continue to intensify as we move forward to this new era in expanding the beneficial returns from space operations. The Space Shuttle is the most important element of an economical, multipurpose space transportation system for access to and from low earth orbit. Its development will provide economical space operations for a wide variety of earth applications, scientific, defense, and technological payloads. The Shuttle will consist of a reusable delta-wing orbiter vehicle with three main engines, an expendable propellant tank, and reusable twin solid rocket boosters. The Shuttle will provide unique capabilities for placement and retrieval of satellites, in-orbit servicing of satellites, and delivery to earth orbit of payloads and propulsive stages for high energy and escape missions. The advent of rapid, economical transportation to and from low earth orbit for both automated payloads and for scientists and other personnel without special flight training, will revolutionize our concepts of using space and will significantly expand the returns from space operations. 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 payload weight, size, and reliability constraints. These advantages will enhance both the flexibility and the productivity of space missions compared to existing expendable launch vehicles.

Space Shuttle development is well underway. All the major elements of the Space Shuttle are under contract, and the design and component fabrication and testing activities are progressing toward the achievement of the first approach and landing test in 1977 and the first manned orbital flight in 1979.

The activities related to the establishment of the space transportation system operations capability will intensify in FY 1977. The Spacelab, which will be a multipurpose payload carrier to be used in the Space Shuttle, will allow scientists, researchers, and technicians to conduct their experiments in the unique environment of space. The Spacelab is being designed and built for NASA by the European Space Agency (ESA), with ten European nations participating in the Spacelab development. The Interim Upper

Stage (IUS) is an upper stage to be used to deploy Shuttle-launched payloads to high energy and escape orbits. The U.S. Air Force will develop the IUS and NASA will define the non-DOD IUS design and operational requirements and develop those items that are unique to NASA and other non-DOD missions.

Other Space Flight efforts include the development of Multiuse Mission Support Equipment, which will consist of ground and flight hardware required for the interface between the payloads and the space transportation system elements. This hardware will be developed into a standard, reusable inventory for all payloads.

FY 1977 Space Flight activities also include expendable launch vehicles for automated projects Launch vehicle hardware, launch services, and engineering support are being provided.

SPACE SCIENCE

The Space Science program utilizes space systems, supported by airborne and ground-based observations, to conduct scientific investigations of the Earth and its atmosphere, the Moon, the Sun, the inner and outer planets, and interplanetary and interstellar space, as well as the other stars of our galaxy and universe. The results from these investigations significantly contribute to our understanding of the universe, including the phenomena that have such a profound effect on life and environment on Earth.

The Sun exerts a primary influence on the Earth. A series of Orbiting Solar Observatory (OSO) missions, including the OSO-8 mission launched in June 1975, has been carried out to study solar phenomena. The discoveries from these missions and from the Apollo Telescope Mount (ATM) experiments flown on Skylab provide the foundation for the Solar Maximum Mission (SMM) planned for initiation in FY 1977. The SMM will provide scientists with the opportunity to study the Sun, including solar flares and other phenomena, during the next period of peak solar activity in 1979-80.

A Small Astronomy Satellite (SAS-3) was launched in June 1975 to expand on the discoveries of the successful SAS-A (Uhuru) project. Two atmosphere explorers (AE-D and E) were launched in October and November and are investigating the physical and chemical processes occurring in the lower regions of the Earth's upper atmosphere.

Work is continuing on the three High Energy Astronomy Observatory (HEAO) missions, planned for launch in 1977, 1978, and 1979. These missions are designed to explore the high energy phenomena observable with X-ray, gamma ray, and cosmic ray instruments. Work is also underway on explorer spacecraft to study ultraviolet astronomy and the sun-earth relationships and on definition of payloads which will capitalize on the unique capabilities of the Space Shuttle/Spacelab.

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During the past year, the Office of Space Science was assigned responsibility for coordinating and consolidating all activities related to upper atmospheric research. The objective of the Upper Atmospheric Research program is to better understand the physics and chemistry of the Earth's atmosphere. Emphasis is being given to assessing the potential impact of chlorofluoromethanes on the atmosphere.

A major highlight of the 1975 activities was the successful launch of two Viking missions to explore the planet Mars. Now in transit, the spacecraft are scheduled for encounter and landing on the surface of Mars in mid-1976. The Viking spacecraft contain scientific apparatus to evaluate the planet's environment and surface conditions and to conduct our first real search for extraterrestrial life.

Following on the successes of Mariner 10, investigation of the planet Venus will continue with two Pioneer missions under development for launch in 1978. One of the missions will gather scientific data while orbiting Venus; the second will launch multiple probes to give us our first detailed in situ measurements of the Venusian atmosphere.

The Helios-1 mission, a cooperative mission with West Germany, was launched in December 1974, and has yielded valuable data on the structure of magnetic fields and energetic particles in regions near the Sun. A second Helios spacecraft was launched in Jaunary 1976.

Exploration of the outer planets continued with the Pioneer 11 encounter of Jupiter in December 1974. The spacecraft is en route to a rendezvous with Saturn in 1979. Its sister spacecraft, Pioneer 10, is on its way to being the first spacecraft to escape our solar system. Two Mariner Jupiter/Saturn missions are under development for launch in 1977.

New data on the physical characteristics of the Moon continue to be gathered by the Apollo Lunar Surface Experiment Packages (ALSEPs). A concentrated scientific effort is underway to analyze and interpret these and other data acquired from lunar flight programs, ground-based observations, laboratory investigations, and lunar sample studies still in process.

The Life Sciences efforts carried out within the Space Science program support research and development programs in space life research, life support and protective systems, bioinstrumentation, planetary biology, and planetary quarantine. The program is designed to provide a basis for enhancing people's ability to work efficiently in space, to develop experiments and related equipment to be flown on Spacelab missions, and to support NASA's efforts in the search for extraterrestrial life. The knowledge gained from the Life Sciences program is made available to the scientific and technical community for application and advancement of research, education, and technology.

APPLICATIONS

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 in the non-space related sector for practical benefits to mankind. These activities are grouped in the following areas: Earth Resources Detection and Monitoring, Earth Dynamics Monitoring and Forecasting, Ocean Condition Monitoring and Forecasting, Environmental Quality Monitoring, Weather and Climate Observation and Forecasting, Materials Processing in Space, Space Communications, Information Management, and Applications Explorer Missions.

In the Earth Resources area, Landsats 1 and 2 are continuing to return valuable data from orbit. Applications Transfer and Demonstration activities are in progress to demonstrate to the user community that remotely obtained data, from satellites and aircraft, provide new capabilities to supplement and extend existing data-gathering capabilities. The most significant of these demonstrations 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, currently under development, will provide thermal infrared data and greater resolution, as well as continuity of experimental data after Landsats 1 and 2 cease to operate. The development of the Thematic Mapper, a second-generation multispectral scanner will provide an instrument with significantly greater performance and resolution than are currently available.

The Earth Dynamics program includes study of the motion of tectonic plates, which is one of the causes of large earthquakes. Measurement of these motions, using both the LAGEOS satellite to be launched in 1976, and accurate ground instruments, will permit a better understanding of this dynamic process and may lead to a capability to predict earthquakes.

The Ocean Condition Monitoring program provides for the study of the oceans from space. Acquiring this type of data for ocean research can lead to major advances in our ability to predict sea conditions. The Seasat-A satellite, now under development, is an essential element in achieving this predictive capability.

The Environmental Quality 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. A significant step forward in this area will occur with the NIMBUS-G satellite currently under development and planned for launch in 1978.

The Weather and Climate program will continue progress in 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 (climate) weather prediction. The major activities in this program are: continued emphasis on applied research and technology; severe storm research; the development of

TIROS-N; and preparation for the first international Global Atmospheric Research program experiment to be conducted in 1978.

The objective of the Materials Processing program is to take advantage of the unique characteristics of zero gravity to prepare and process materials in ways that are not possible or economically practical on earth. Efforts will continue in laboratory experiments and use of small rockets to obtain weightless conditions for short periods to contribute to future development of experiments that will be flown on the Shuttle/Spacelab.

The current NASA effort in space communications 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 agencies. The highly successful series of Applications Technology Satellites (ATS-1, 3, 5, 6) and the cooperative U.S./Canadian Satellite CAS-C will continue to be used by various domestic and international experimenters. Significant effort will be devoted to support of U.S. participation in the 1979 World Administrative Radio Conference, the first of its kind since 1959.

Information Management activities involve 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, and to provide the user with improved capabilities for rapidly storing, maintaining, and retrieving the required data products.

The Applications Explorer Missions program was established to develop small, low cost, Scout-launched spacecraft tailored to specific areas of research and orbital requirements. This program includes the Heat Capacity Mapping Mission (AEM-A) to provide thermal data for studies of soil moisture, and mapping of thermal effluents; the Stratospheric Aerosol and Gas Experiment (AEM-B), to develop measurement techniques for the detection and mapping of stratospheric aerosols and ozone; and the Magnetic Field Satellite, called MAGSAT (AEM-C), to map the magnitude and direction of the Earth's global magnetic field with improved accuracy. MAGSAT is also expected to yield useful information for locating natural resources, such as coal, oil, and minerals.

AERONAUTICS AND SPACE TECHNOLOGY

The objectives of the Aeronautics program continue to be the advancement of aeronautical technology to ensure safer, more economical, efficient and environmentally acceptable air transportation systems which are responsive to current and projected national needs. This technology is necessary to help maintain the strong competitive position of the United States in the international aviation marketplace and to aid the military in maintaining the superiority of the nation's military aircraft.

A strong research effort will be maintained in the disciplinary areas of materials, structures, propulsion, avionics, aerodynamics and human-vehicle interactions to provide advanced technology to meet the future needs of civil aviation. The program will continue to focus on developing the technology to improve performance, reduce energy requirements, enhance operating efficiency, reduce undesirable environmental effects, improve safety and reliability, and improve terminal area operations for all types of aircraft. These technology efforts are integrated with additional focused technology efforts to develop advanced long haul and short haul air transportation system concepts.

Aircraft energy efficiency technology efforts represent a refocusing within the aeronautical research program to place added emphasis on those technologies that will lead to more energy efficient derivatives and/or retrofits of current aircraft, as well as to more energy efficient designs of future aircraft. These technology efforts evolved as a result of a study involving other agencies and the aircraft and airline industries which identified the most crucial areas with the most probable payoff in increased aircraft efficiency and the greatest need for NASA involvement. The five principal areas of activity are: Engine Component Improvement; Energy Efficient Engines; Laminar Flow Control; Energy Efficient Transport; and Composite Primary Aircraft Structures.

The objectives of the Space Research and Technology program are to provide a technology base which will adequately support current and future space activities, and implement approaches for further reducing the costs of future space activities through standardization.

A strong research effort will be maintained in the areas of materials, structures, fundamental electronics, guidance and control, information systems, chemical and electric propulsion, energy systems and aerothermodynamics. Systems Studies will be pursued to investigate future space mission alternatives and to identify and evaluate the technology requirements of future missions. Systems Technology efforts will continue toward extending the temperature limits for composite materials to allow their use on advanced space transportation systems, and toward providing a no-moving-part data storage system for aerospace vehicles. Increased activity in the Space Technology Payloads program is aimed at defining a series of flight experiments that will fly on the Space Shuttle during the early 1980's.

In the Low Cost Systems area, the primary emphasis will continue to be on the development and upgrading of various standard spacecraft components in an effort toward reducing the overall cost of space systems.

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 the Spaceflight Tracking and Data Network include the High Energy Astronomical Observatory (HEAO), the International Ultraviolet Explorer (IUE), and many other international missions and missions of other U.S. agencies. Additions to the support workload of the Deep Space Network include the Viking extended mission and the Mariner Jupiter/Saturn missions in 1977.

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 support essentially all earth orbital spacecraft missions and will greatly improve NASA's earth orbital tracking and data acquisition capabilities. NASA plans to acquire this capability through a contract for services arrangement under which the contractor will establish the system and provide NASA with TDRSS services for a period of ten years. Therefore, NASA funding for these services will not be required until the services commence in FY 1979.

ENERGY TECHNOLOGY APPLICATIONS

Energy research and technology efforts in NASA have been primarily directed toward identifying the technology developed in the aeronautics and space program which has potential for making major contributions to the solution of energy problems on earth and supporting the programs undertaken by other agencies to develop specific applications such as photovoltaics (solar cells), solar heating and cooling, and electric power generation by wind power. No direct NASA R&D funding is contained in the FY 1977 budget; however, NASA will continue to make its considerable capabilities and expertise available to ERDA and other agencies, as requested, to proceed with energy technology activities on a reimbursable basis.

TECHNOLOGY UTILIZATION

The objective is to accelerate and expand the application and use of aerospace-developed technology in the private and public sectors.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

Federal Funds

General and special funds:

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 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, [$2,677,380,000] *$2,758,925,000*, to remain available until expended.

[For "Research and development," to be available July 1, 1976, $700,600,000, to remain available until expended.] (*42 U.S.C. 2451, et seq.; Department of Housing and Urban Development—Independent Agencies Appropriation Act, 1976; additional authorizing legislation to be proposed.*)

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			
	1975 actual	1976 estimate	TQ estimate	1977 estimate	1975 actual	1976 estimate	TQ estimate	1977 estimate
Program by activities:								
Direct program:								
1. Space flight:								
(a) Space shuttle	797,500	1,206,000	321,000	1,288,100	864,667	1,143,000	321,000	1,282,700
(b) Space flight operations	298,800	188,600	48,400	205,200	336,985	215,300	48,100	202,800
(c) Expendable launch vehicle development and support	92,000	97,100	22,400	87,600	94,105	95,200	24,900	90,900
(d) Apollo					1,130	300		
2. Scientific investigations in space:								
(a) Physics and astronomy	150,815	184,300	48,700	188,300	145,421	187,500	42,600	177,700
(b) Lunar and planetary exploration	282,900	291,200	76,400	218,300	336,675	314,700	77,700	234,700
(c) Life sciences	19,800	20,800	5,200	22,125	23,793	20,100	5,200	24,300
3. Space applications	186,048	184,930	48,500	212,300	164,786	203,600	52,400	212,100
4. Space research and technology	75,800	80,800	20,800	82,000	81,526	83,100	19,700	83,500
5. Aeronautical research and technology	166,400	175,350	43,800	189,100	161,731	181,100	49,500	180,100
6. Supporting activities:								
(a) Tracking and data acquisition	248,000	240,800	63,400	258,000	258,535	260,100	63,700	258,600
(b) Sustaining university program					212	400		
(c) Technology utilization	5,500	7,500	2,000	7,900	4,919	7,600	1,300	6,600
Total direct program costs, funded	2,323,563	2,677,380	700,600	2,758,925	2,476,885	2,712,000	706,100	2,752,000
Reimbursable program:								
1. Space flight:								
(a) Space shuttle	442	258	50	300	486	300		300
(b) Space flight operations	8,332	5,814	1,427	5,535	9,174	8,790	1,400	5,500
2. Scientific investigations in space:								
(a) Physics and astronomy	10,135	8,887	278	4,725	9,760	8,300	1,300	5,900
(b) Lunar and planetary exploration	66				66			
(c) Life sciences	122				28	110		
3. Space applications	179,528	175,874	29,405	129,910	148,896	184,500	28,400	156,900
4. Space research and technology	918	20			−313	1,300		300
5. Aeronautical research and technology	17,322	19,237	3,800	15,355	24,816	25,400	3,800	15,400
6. Supporting activities:								
(a) Tracking and data acquisition	580	485	50	400	232	1,000	100	400
(b) Technology utilization	3,702	4,425	1,190	5,675	4,051	4,400	1,200	5,700
7. Energy technology applications	10,322	49,100	15,400	82,700	6,253	30,000	15,400	54,200
Total reimbursable program costs	231,469	264,100	51,600	244,600	203,449	264,100	51,600	244,600
Total program costs, funded	2,555,032	2,941,480	752,200	3,003,525	2,580,334	2,976,100	757,700	2,996,600
Change in selected resources (undelivered orders and stores)					−68,419	310,735	−5,500	6,925
10 Total	2,555,032	2,941,480	752,200	3,003,525	2,611,915	3,286,835	752,200	3,003,525

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			
	1975 actual	1976 estimate	TQ estimate	1977 estimate	1975 actual	1976 estimate	TQ estimate	1977 estimate
Financing:								
Receipts and reimbursements from:								
11 Federal funds	−84,093	−118,695	−30,553	−164,496	−84,093	−118,695	−30,553	−164,496
14 Non-Federal sources	−147,376	−145,405	−21,047	−80,104	−147,376	−145,405	−21,047	−80,104
21 Unobligated balance available, start of period:								
For completion of prior period budget plans:								
Direct					−310,380	−235,322		
Reimbursable					−92,190	−110,033		
24 Unobligated balance available, end of period:								
For completion of prior period budget plans:								
Direct					235,322			
Reimbursable					110,033			
25 Unobligated balance lapsing					352			
Budget authority	2,323,563	2,677,380	700,600	2,758,925	2,323,563	2,677,380	700,600	2,758,925
Budget authority:								
40 Appropriation	2,331,015	2,677,380	700,600	2,758,925	2,331,015	2,677,380	700,600	2,758,925
41 Transferred to other accounts	−7,452				−7,452			
43 **Appropriation (adjusted)**	2,323,563	2,677,380	700,600	2,758,925	2,323,563	2,677,380	700,600	2,758,925
Relation of obligations to outlays:								
71 Obligations incurred, net					2,380,446	3,022,735	700,600	2,758,925
72 Obligated balance, start of period					771,594	731,653	1,146,688	1,191,388
74 Obligated balance, end of period					−731,653	−1,146,688	−1,191,388	−1,214,013
90 Outlays					2,420,387	2,607,700	655,900	2,736,300

Note.—Reconciliation of budget plan to obligations:	1975 actual	1976 estimate	TQ estimate	1977 estimate
Total budget plan	2,555,032	2,941,480	752,200	3,003,525
Deduct portion of budget plan to be obligated in subsequent periods	227,353			
Add obligations of prior period budget plans	284,236	345,355		
Total obligations	2,611,915	3,286,835	752,200	3,003,525

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

BUDGET PLAN SUMMARY

Code		FY 1975	FY 1976	Transition Quarter	FY 1977
			(Thousands of Dollars)		
	SPACE FLIGHT	1,235,800	1,560,500	406,500	1,644,700
253	Space shuttle	797,500	1,206,000	321,000	1,288,100
253	Space flight operations	298,800	188,600	48,400	205,200
254	Expendable launch vehicles	139,500	165,900	37,100	151,400
	SPACE SCIENCE	417,315	434,200	116,400	379,025
254	Physics and astronomy	136,315	159,300	43,500	165,800
254	Lunar and planetary exploration	261,200	254,100	67,700	191,100
253	Life science	19,800	20,800	5,200	22,125
	APPLICATIONS	174,748	178,230	47,700	198,200
254	Space applications	174,748	178,230	47,700	198,200
	AERONAUTICS AND SPACE TECHNOLOGY	237,765	250,250	63,100	271,100
405	Aeronautical research and technology	166,400	175,350	43,800	189,100
254	Space research and technology	71,365	74,900	19,300	82,000
254	ENERGY PROGRAMS	4,435	5,900	1,500	---
255	TRACKING AND DATA ACQUISITION	248,000	240,800	63,400	258,000
255	TECHNOLOGY UTILIZATION	5,500	7,500	2,000	7,900
	TOTAL	2,323,563	2,677,380	700,600	2,758,925

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

SUMMARY OF BUDGET PLAN BY SUBFUNCTION

Code		FY 1975	FY 1976	Transition Quarter	FY 1977
			(Thousands of Dollars)		
253	Space Flight	1,116,100	1,415,400	374,600	1,515,425
254	Space Science, Applications and Technology	787,563	838,330	216,800	788,500
255	Supporting Space Activities	253,500	248,300	65,400	265,900
(250)	Subtotal, General Science, Space and Technology	2,157,163	2,502,030	656,800	2,569,825
405	Air Transportation	166,400	175,350	43,800	189,100
	Total	2,323,563	2,677,380	700,600	2,758,925

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1977 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 SPACE FLIGHT, TOTAL	1975	1,235,800	741,238	101,237	228,965	1,434	47,014	651	10	540	---	11,815	68,275	34,621
	1976	1,560,500	948,954	109,075	329,310	9,940	37,714	796	---	1,244	714	11,065	95,605	16,083
	TQ	406,500	243,403	35,605	87,060	2,500	7,930	250	---	200	---	3,500	22,300	3,752
	1977	1,644,700	915,488	166,463	404,757	11,200	38,427	550	---	365	---	10,750	77,300	19,400
Space shuttle	1975	797,500	625,260	12,300	131,898	345	68	---	---	---	---	28	---	7,601
	1976	1,206,000	854,294	52,800	284,200	2,800	189	---	---	760	714	341	---	9,902
	TQ	321,000	218,200	23,900	75,200	700	---	---	---	---	---	---	---	3,000
	1977	1,288,100	814,500	105,200	353,200	4,200	---	---	---	---	---	---	---	11,000
Space flight operations	1975	298,800	115,978	77,320	77,067	1,089	488	651	---	540	---	402	200	25,065
	1976	188,600	94,660	38,000	45,110	7,140	525	796	---	484	---	274	155	1,456
	TQ	48,400	25,203	8,310	11,860	1,800	200	250	---	200	---	200	100	277
	1977	205,200	100,988	42,940	51,557	7,000	400	550	---	365	---	200	200	1,000
Expendable launch vehicles	1975	139,500	---	11,617	---	---	46,458	---	10	---	---	11,385	68,075	1,955
	1976	165,900	---	18,275	---	---	37,000	---	---	---	---	10,450	95,450	4,725
	TQ	37,100	---	3,395	---	---	7,730	---	---	---	---	3,300	22,200	475
	1977	151,400	---	18,323	---	---	38,027	---	---	---	---	10,550	77,100	7,400
OFFICE OF SPACE SCIENCE, TOTAL	1975	417,315	18,845	18	50,942	---	64,327	91,690	2,459	32,088	106	95,192	---	41,648
	1976	434,200	17,852	100	74,467	---	62,289	100,684	3,730	77,695	100	49,673	---	47,610
	TQ	116,400	4,390	---	19,152	---	15,081	26,240	941	19,893	---	16,046	---	14,657
	1977	379,025	20,383	1,000	46,250	---	83,968	73,950	3,950	63,095	100	28,348	1,600	56,381
Physics and astronomy	1975	136,315	947	---	50,029	---	55,940	628	2,404	7,126	---	1,358	---	17,883
	1976	159,300	1,237	---	73,967	---	54,122	958	3,675	7,145	---	697	---	17,499
	TQ	43,500	300	---	19,037	---	13,934	170	926	1,293	---	281	---	7,539
	1977	165,800	2,458	---	46,250	---	74,843	1,700	3,900	6,500	---	1,340	1,600	27,209
Lunar and planetary exploration	1975	261,200	12,100	---	60	---	8,387	89,636	55	36,971	---	93,784	---	20,207
	1976	254,100	10,815	---	---	---	8,167	98,226	55	62,203	---	48,976	---	25,658
	TQ	67,700	2,250	---	---	---	1,127	25,735	15	16,950	---	15,765	---	5,858
	1977	191,100	11,925	---	---	---	8,625	70,150	50	48,220	---	27,008	---	25,122
Life sciences	1975	19,800	5,798	18	853	---	---	1,426	---	7,991	106	50	---	3,558
	1976	20,800	5,800	100	500	---	---	1,500	---	8,347	100	---	---	4,453
	TQ	5,200	1,840	---	115	---	---	335	---	1,650	---	---	---	1,260
	1977	22,125	6,000	1,000	---	---	500	2,100	---	8,375	100	---	---	4,050

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 APPLICATIONS, (Space applications)	1975	174,748	32,262	1,227	7,691	265	91,095	10,549	6,734	5,980	---	9,653	2,732	6,560
	1976	178,230	30,863	710	7,225	543	86,889	15,372	6,430	7,169	---	9,631	3,292	10,106
	TQ	47,700	6,934	95	2,364	38	25,817	4,990	1,508	1,900	---	2,838	492	724
	1977	198,200	32,815	700	11,155	548	89,953	28,980	5,542	8,553	---	9,324	2,732	7,898
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, TOTAL	1975	237,765	271	---	2,595	---	5,358	18,661	345	57,047	13,588	76,717	59,017	4,166
	1976	250,250	644	50	3,105	---	5,763	18,035	460	53,247	17,770	81,675	63,742	5,759
	TQ	63,100	290	30	857	---	1,217	4,780	265	10,664	4,845	22,451	16,586	1,115
	1977	271,100	1,985	---	3,189	---	8,362	19,142	420	42,598	17,015	99,994	72,896	5,499
Aeronautical research and technology	1975	166,400	100	---	670	---	---	1,540	290	48,023	12,683	61,781	39,511	1,802
	1976	175,350	350	---	740	---	100	730	405	44,953	16,820	63,966	44,737	2,549
	TQ	43,800	225	---	125	---	---	262	250	8,558	4,845	17,566	11,431	538
	1977	189,100	575	---	800	---	200	1,215	365	33,708	17,015	80,309	52,403	2,510
Space research and technology	1975	71,365	171	---	1,925	---	5,358	17,121	55	9,024	905	14,936	19,506	2,364
	1976	74,900	294	50	2,365	---	5,663	17,305	55	8,294	950	17,709	19,005	3,210
	TQ	19,300	65	30	732	---	1,217	4,518	15	2,106	---	4,885	5,155	577
	1977	82,000	1,410	---	2,389	---	8,162	17,927	55	8,890	---	19,685	20,493	2,989
OFFICE OF TRACKING AND DATA ACQUISITION	1975	248,000	---	---	4	---	175,949	49,297	5,057	---	2,470	---	---	15,223
	1976	240,800	---	---	---	---	167,800	51,800	4,300	---	2,300	---	---	14,600
	TQ	63,400	---	---	---	---	44,200	14,350	1,250	---	600	---	---	3,000
	1977	258,000	---	---	---	---	181,900	54,800	4,800	---	2,500	---	---	14,000
OFFICE OF TECHNOLOGY UTILIZATION	1975	5,500	388	40	58	---	350	473	15	438	---	455	80	3,203
	1976	7,500	566	110	408	53	547	694	15	718	---	645	250	3,494
	TQ	2,000	100	25	100	---	100	200	---	150	---	125	50	1,150
	1977	7,900	600	100	400	50	350	520	15	680	---	440	250	4,495
ENERGY TECHNOLOGY APPLICATIONS	1975	4,435	43	---	615	---	75	2,399	---	160	---	160	555	428
	1976	5,900	1,315	---	525	---	160	1,900	---	185	---	---	1,815	---
	TQ	1,500	180	---	235	---	25	700	---	50	---	---	310	---
	1977	---	---	---	---	---	---	---	---	---	---	---	---	---
TOTAL BUDGET PLAN	1975	2,323,563	793,047	102,522	290,870	1,699	384,168	173,720	44,620	116,253	16,164	193,992	130,659	105,849
	1976	2,677,380	1,000,194	110,045	413,040	10,536	361,162	189,281	14,935	140,258	20,884	152,689	164,704	97,652
	TQ	700,600	255,297	35,755	109,768	2,538	94,370	51,510	3,964	32,857	5,445	44,960	39,738	24,398
	1977	2,758,925	971,271	168,263	465,751	11,798	402,960	177,942	14,727	115,291	19,615	148,856	154,778	107,673

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RECONCILIATION OF FY 1976 BUDGET STRUCTURE TO CURRENT STRUCTURE

RESEARCH AND DEVELOPMENT - FY 1975 (ACTUAL) PLAN
(Millions of Dollars)

PREVIOUS STRUCTURE	CURRENT STRUCTURE												
	FY 1975 Plan	Space Shuttle	Space Flight Operations	Expendable Launch Vehicles	Physics & Astronomy	Lunar & Planetary Exploration	Life Sciences	Space Applications	Aeronautical Research & Technology	Space Research & Technology	Energy Technology Applications	Tracking and Data Acquisition	Technology Utilization
Space shuttle	797.5	797.5	---	---	---	---	---	---	---	---	---	---	---
Space flight operations	311.3	---	296.3	---	---	---	15.0	---	---	---	---	---	---
Advanced missions	1.5	---	1.5	---	---	---	---	---	---	---	---	---	---
Physics and astronomy	136.3	---	---	---	136.3	---	---	---	---	---	---	---	---
Lunar and planetary exploration	266.0	---	---	---	---	261.2	4.8	---	---	---	---	---	---
Launch vehicle procurement	140.5	---	1.0	139.5	---	---	---	---	---	---	---	---	---
Space applications	174.8	---	---	---	---	---	---	174.8	---	---	---	---	---
Aeronautical research and technology	166.4	---	---	---	---	---	---	---	166.4	---	---	---	---
Space and nuclear research and technology	71.4	---	---	---	---	---	---	---	---	71.4	---	---	---
Energy technology applications	4.4	---	---	---	---	---	---	---	---	---	4.4	---	---
Tracking and data acquisition	248.0	---	---	---	---	---	---	---	---	---	---	248.0	---
Technology utilization	5.5	---	---	---	---	---	---	---	---	---	---	---	5.5
FY 1975 Budget	2,323.6	797.5	298.8	139.5	136.3	261.2	19.8	174.8	166.4	71.4	4.4	248.0	5.5

SUM 15

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RECONCILIATION OF FY 1976 BUDGET STRUCTURE TO CURRENT STRUCTURE

RESEARCH AND DEVELOPMENT - FY 1976 BUDGET PLAN
(Millions of Dollars)

PREVIOUS STRUCTURE	CURRENT STRUCTURE												
	FY 1976 Budget Plan	Space Shuttle	Space Flight Operations	Expendable Launch Vehicles	Physics & Astronomy	Lunar & Planetary Exploration	Life Sciences	Space Applications	Aeronautical Research & Technology	Space Research & Technology	Energy Technology Applications	Tracking and Data Acquisition	Technology Utilization
Space shuttle.....	1,206.0	1,206.0	---	---	---	---	---	---	---	---	---	---	---
Space flight operations	207.1	---	191.1	---	---	---	16.0	---	---	---	---	---	---
Advanced missions.....	1.5	---	1.5	---	---	---	---	---	---	---	---	---	---
Physics and astronomy...	155.8	---	---	---	155.8	---	---	---	---	---	---	---	---
Lunar and planetary exploration.....	259.9	---	---	---	---	255.1	4.8	---	---	---	---	---	---
Launch vehicle procurement.....	166.9	---	1.0	165.9	---	---	---	---	---	---	---	---	---
Space applications.....	175.0	---	---	---	---	---	---	175.0	---	---	---	---	---
Aeronautical research and technology.....	175.4	---	---	---	---	---	---	---	175.4	---	---	---	---
Space and nuclear research and technology	74.9	---	---	---	---	---	---	---	---	74.9	---	---	---
Energy technology applications.....	5.9	---	---	---	---	---	---	---	---	---	5.9	---	---
Tracking and data acquisition.....	243.0	---	---	---	---	---	---	---	---	---	---	243.0	---
Technology utilization..	7.0	---	---	---	---	---	---	---	---	---	---	---	7.0
Budget Estimate.....	2,678.4	1,206.0	193.6	165.9	155.8	255.1	20.8	175.0	175.4	74.9	5.9	243.0	7.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RECONCILIATION OF FY 1976 BUDGET STRUCTURE TO CURRENT STRUCTURE

RESEARCH AND DEVELOPMENT - TRANSITION QUARTER BUDGET PLAN
(Millions of Dollars)

PREVIOUS STRUCTURE	CURRENT STRUCTURE												
	Transition Quarter Budget Plan	Space Shuttle	Space Flight Operations	Expendable Launch Vehicles	Physics & Astronomy	Lunar & Planetary Exploration	Life Sciences	Space Applications	Aeronautical Research & Technology	Space Research & Technology	Energy Technology Applications	Tracking and Data Acquisition	Technology Utilization
Space shuttle	321.0	321.0	---	---	---	---	---	---	---	---	---	---	---
Space flight operations	55.1	---	50.3	---	---	---	4.8	---	---	---	---	---	---
Advanced missions	.5	---	.5	---	---	---	---	---	---	---	---	---	---
Physics and astronomy	46.6	---	---	---	46.6	---	---	---	---	---	---	---	---
Lunar and planetary exploration	73.3	---	---	---	---	72.4	.9	---	---	---	---	---	---
Launch vehicle procurement	40.4	---	.3	40.1	---	---	---	---	---	---	---	---	---
Space applications	54.7	---	---	---	---	---	---	54.7	---	---	---	---	---
Aeronautical research and technology	46.8	---	---	---	---	---	---	---	46.8	---	---	---	---
Space and nuclear research and technology	22.3	---	---	---	---	---	---	---	---	22.3	---	---	---
Energy technology applications	1.5	---	---	---	---	---	---	---	---	---	1.5	---	---
Tracking and data acquisition	66.4	---	---	---	---	---	---	---	---	---	---	66.4	---
Technology utilization	2.0	---	---	---	---	---	---	---	---	---	---	---	2.0
Budget Estimate	730.6	321.0	51.1	40.1	46.6	72.4	5.7	54.7	46.8	22.3	1.5	66.4	2.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RECONCILIATION OF FY 1976 BUDGET STRUCTURE TO CURRENT STRUCTURE

RESEARCH AND DEVELOPMENT - FY 1975 PLAN (ACTUAL)
(Millions of Dollars)

PREVIOUS STRUCTURE	CURRENT STRUCTURE										
		SPACE FLIGHT							SPACE SCIENCE		
			SPACE FLIGHT OPERATIONS								
OFFICE/PROGRAM	FY 1975 Plan	Space Shuttle	DTMO	STS Operations Capability Development	Advanced Program	ASTP	Total	Expendable Launch Vehicles	Physics and Astronomy	Lunar and Planetary Exploration	Life Sciences
SPACE FLIGHT											
Space Shuttle	797.5	797.5	---	---	---	---	---	---	---	---	---
Space Flight Operations	311.3	---	170.2	3.0	13.5	109.6	296.3	---	---	---	15.0
Development, test and mission operations (DTMO)	170.2	---	170.2	---	---	---	170.2	---	---	---	---
Space life sciences	18.0	---	---	---	3.0	---	3.0	---	---	---	15.0
Mission systems and integration:	(13.5)										
Payload integration and mission analysis	5.0	---	---	---	5.0	---	5.0	---	---	---	---
Spacelab/concept verification testing	2.0	---	---	2.0	---	---	2.0	---	---	---	---
Advanced development	5.5	---	---	---	5.5	---	5.5	---	---	---	---
Interim upper stage/ Space Tug	1.0	---	---	1.0	---	---	1.0	---	---	---	---
ASTP	109.6	---	---	---	---	109.6	109.6	---	---	---	---
Advanced Missions	1.5	---	---	---	1.5	---	1.5	---	---	---	---
SPACE SCIENCE											
Physics and Astronomy	136.3	---	---	---	---	---	---	---	136.3	---	---
Lunar and Planetary Exploration	266.0	---	---	---	---	---	---	---	---	261.2	4.8
Planetary quarantine	1.5	---	---	---	---	---	---	---	---	---	1.5
Exobiology(SRT/Adv Studies)	3.3	---	---	---	---	---	---	---	---	---	3.3
All other projects	261.2	---	---	---	---	---	---	---	---	261.2	---
Launch Vehicle Procurement	140.5	---	---	---	1.0	---	1.0	139.5	---	---	---
Supporting research and technology/adv studies	1.0	---	---	---	1.0	---	1.0	---	---	---	---
All other projects	139.5	---	---	---	---	---	---	139.5	---	---	---
Total	---	797.5	170.2	3.0	16.0	109.6	298.8	139.5	136.3	261.2	19.8

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RECONCILIATION OF FY 1976 BUDGET STRUCTURE TO CURRENT STRUCTURE

RESEARCH AND DEVELOPMENT - FY 1976 BUDGET PLAN
(Millions of Dollars)

PREVIOUS STRUCTURE	CURRENT STRUCTURE									
		SPACE FLIGHT						SPACE SCIENCE		
			SPACE FLIGHT OPERATIONS							
OFFICE/PROGRAM	Total in FY 1976 Budget	Space Shuttle	DTMO	STS Operations Capability Development	Advanced Programs	Total	Expendable Launch Vehicles	Physics and Astronomy	Lunar and Planetary Exploration	Life Sciences
SPACE FLIGHT										
Space Shuttle	1,206.0	1,206.0	---	---	---	---	---	---	---	---
Space Flight Operations	207.1	---	166.1	9.5	15.5	191.1	---	---	---	16.0
Development, test and mission operations (DTMO)	166.1	---	166.1	---	---	166.1	---	---	---	---
Space life sciences	19.0	---	---	---	3.0	3.0	---	---	---	16.0
Mission systems and integration:	(22.0)									
Payload integration and mission analysis	6.0	---	---	---	6.0	6.0	---	---	---	---
Spacelab/concept verification testing	6.1	---	---	6.1	---	6.1	---	---	---	---
Advanced development	6.5	---	---	---	6.5	6.5	---	---	---	---
Interim upper stage/ Space Tug	3.4	---	---	3.4	---	3.4	---	---	---	---
Advanced Missions	1.5	---	---	---	1.5	1.5	---	---	---	---
SPACE SCIENCE										
Physics and Astronomy	155.8	---	---	---	---	---	---	155.8	---	---
Lunar and Planetary Exploration	259.9	---	---	---	---	---	---	---	255.1	4.8
Planetary quarantine	1.5	---	---	---	---	---	---	---	---	1.5
Exobiology (SRT/Adv Studies)	3.3	---	---	---	---	---	---	---	---	3.3
All other projects	255.1	---	---	---	---	---	---	---	255.1	---
Launch Vehicle Procurement	166.9	---	---	---	1.0	1.0	165.9	---	---	---
Supporting research and technology/adv studies	1.0	---	---	---	1.0	1.0	---	---	---	---
All other projects	165.9	---	---	---	---	---	165.9	---	---	---
Budget Estimate	---	1,206.0	166.1	9.5	18.0	193.6	165.9	155.8	255.1	20.8

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RECONCILIATION OF FY 1976 BUDGET STRUCTURE TO CURRENT STRUCTURE

RESEARCH AND DEVELOPMENT - TRANSITION QUARTER BUDGET PLAN
(Millions of Dollars)

PREVIOUS STRUCTURE	CURRENT STRUCTURE									
		SPACE FLIGHT						SPACE SCIENCE		
			SPACE FLIGHT OPERATIONS							
OFFICE/PROGRAM	Total in Transition Quarter Budget	Space Shuttle	DTMO	SIS Operations Capability Development	Advanced Programs	Total	Expendable Launch Vehicles	Physics and Astronomy	Lunar and Planetary Exploration	Life Sciences
SPACE FLIGHT										
Space Shuttle	321.0	321.0	---	---	---	---	---	---	---	---
Space Flight Operations	55.1	---	43.2	2.6	4.5	50.3	---	---	---	4.8
Development, test and mission operations (DTMO)	43.2	---	43.2	---	---	43.2	---	---	---	---
Space life sciences	5.5	---	---	---	.7	.7	---	---	---	4.8
Mission systems and integration:	(6.4)									
Payload integration and mission analysis	1.8	---	---	---	1.8	1.8	---	---	---	---
Spacelab/concept verification	1.9	---	---	1.9	---	1.9	---	---	---	---
Advanced development	2.0	---	---	---	2.0	2.0	---	---	---	---
Interim upper stage/ Space Tug	.7	---	---	.7	---	.7	---	---	---	---
Advanced Missions	.5	---	---	---	.5	.5	---	---	---	---
SPACE SCIENCE										
Physics and Astronomy	46.6	---	---	---	---	---	---	46.6	---	---
Lunar and Planetary Exploration	73.3	---	---	---	---	---	---	---	72.4	.9
Planetary quarantine	.4	---	---	---	---	---	---	---	.1	.3
Exobiology (SRT/Adv Studies)	.6	---	---	---	---	---	---	---	---	.6
All other projects	72.3	---	---	---	---	---	---	---	72.3	---
Launch Vehicle Procurement	40.4	---	---	---	.3	.3	40.1	---	---	---
Supporting research and technology/adv studies	.3	---	---	---	.3	.3	---	---	---	---
All other projects	40.1	---	---	---	---	---	40.1	---	---	---
Budget Estimate	---	321.0	43.2	2.6	5.3	51.1	40.1	46.6	72.4	5.7

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RECONCILIATION OF FY 1976 BUDGET STRUCTURE TO CURRENT STRUCTURE

RESEARCH AND DEVELOPMENT SPACE APPLICATIONS PROGRAM - FY 1975 PROGRAM (ACTUAL)
(Millions of Dollars)

PREVIOUS STRUCTURE	CURRENT STRUCTURE									
	FY 1975 Plan	Earth Resources Detection & Monitoring	Earth Dynamics Monitoring & Forecasting	Ocean Condition Monitoring & Forecasting	Environmental Quality Monitering	Weather and Climate Observation & Forecasting	Materials Processing in Space	Space Communi-cations	Information Management	Applications Explorer Missions
Weather and climate	36.5	.4	---	---	---	36.1	---	---	---	---
Pollution monitoring	22.4	---	---	---	22.4	---	---	---	---	---
Earth resources survey:	(60.9)									
Airborne research	15.5	8.1								
Other projects	45.4	45.4	.5	3.7	.7	2.5	---	---	---	---
Earth and ocean physics	18.9	---	---	---	---	---	---	---	---	---
Space processing	3.3	---	7.7	11.2	---	---	---	---	---	---
Communications	11.0	---	---	---	---	---	---	---	---	---
Data management	4.0	---	---	---	---	---	3.3	---	---	---
Payloads	4.5	1.7	.2	---	1.2	.4	.5	.5	---	---
Advanced applications flight experiments	4.7	.6	.9	.1	1.4	1.1	.5	.1	---	---
Applications systems analyses	5.0	1.5	.3	.6	.7	1.0	.3	.4	.2	---
Applications explorer missions	2.6	---	---	---	---	---	---	---	---	2.6
Earth observation satellite definition	1.0	1.0	---	---	---	---	---	---	---	---
Total	174.8	58.7	9.6	15.6	26.4	42.1	4.6	12.0	3.2	2.6

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RECONCILIATION OF FY 1976 BUDGET STRUCTURE TO CURRENT STRUCTURE

RESEARCH AND DEVELOPMENT SPACE APPLICATIONS PROGRAM - FY 1976 BUDGET PLAN
(Millions of Dollars)

PREVIOUS STRUCTURE	CURRENT STRUCTURE									
	Total in FY 1976 Budget	Earth Resources Detection & Monitoring	Earth Dynamics Monitoring & Forecasting	Ocean Condition Monitoring & Forecasting	Enviromental Quality Monitoring	Weather and Climate Observation & Forecasting	Materials Processing in Space	Space Communi-cations	Information Management	Applications Explorer Missions
Weather and climate	33.6	---	---	---	---	33.6	---	---	---	---
Pollution monitoring	19.2	---	---	---	19.2	---	---	---	---	---
Earth resources survey:	(62.0)									
Airborne research	13.3	5.7	.3	2.4	2.6	2.3	---	---	---	---
Other projects	48.7	48.7	---	---	---	---	---	---	---	---
Earth and ocean physics	26.4	---	6.9	19.5	---	---	---	---	---	---
Space processing	3.7	---	---	---	---	---	3.7	---	---	---
Communications	7.5	---	---	---	---	---	---	7.5	---	---
Data management	4.0	---	---	---	---	1.0	---	---	3.0	---
Payloads	3.0	1.1	.2	---	.5	.2	.8	.2	---	---
Advanced applications flight experiments	4.7	.6	.3	.3	1.3	1.6	.5	.1	---	---
Applications systems analyses	5.0	1.6	.3	.6	.6	1.0	.3	.4	.2	---
Applications explorer missions	5.9	---	---	---	---	---	---	---	---	5.9
Budget Estimate	175.0	57.7	8.0	22.8	24.2	39.7	5.3	8.2	3.2	5.9

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RECONCILIATION OF FY 1976 BUDGET STRUCTURE TO CURRENT STRUCTURE

RESEARCH AND DEVELOPMENT SPACE APPLICATIONS PROGRAM - TRANSITION QUARTER
(Millions of Dollars)

PREVIOUS STRUCTURE	CURRENT STRUCTURE									
	Total in Transition Quarter Budget	Earth Resources Detection & Monitoring	Earth Dynamics Monitoring & Forecasting	Ocean Condition Monitoring & Forecasting	Environmental Quality Monitoring	Weather and Climate Observation & Forecasting	Materials Processing in Space	Space Communi-cations	Information Management	Applications Explorer Missions
Weather and climate	11.7	---	---	---	---	11.7	---	---	---	---
Pollution monitoring	8.7	---	---	---	8.7	---	---	---	---	---
Earth resources survey:	(15.0)									
Airborne research	3.6	1.2	.1	.9	.7	.7	---	---	---	---
Other projects	11.4	11.4	---	---	---	---	---	---	---	---
Earth and ocean physics	7.8	---	2.1	5.7	---	---	---	---	---	---
Space processing	1.2	---	---	---	---	---	1.2	---	---	---
Communications	2.0	---	---	---	---	---	---	2.0	---	---
Data management	1.5	---	---	---	---	.3	---	---	1.2	---
Payloads	1.5	.9	---	---	.4	.1	---	.1	---	---
Advanced applications flight experiments	1.3	.2	.1	---	.6	.2	.1	.1	---	---
Applications systems analyses	1.4	.3	.1	.2	.2	.2	.1	.2	.1	---
Applications explorer missions	2.6	---	---	---	---	---	---	---	---	2.6
Budget Estimate	54.7	14.0	2.4	6.8	10.6	13.2	1.4	2.4	1.3	2.6

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1977 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE FLIGHT PROGRAMS

	Budget Plan					
		1976		Transition Quarter		1977
	1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
	(Thousands of Dollars)					
Space Shuttle.....	797,500	1,206,000	1,206,000	321,000	321,000	1,288,100
Space Flight Operations.....	298,800	193,600	188,600	51,100	48,400	205,200
Expendable Launch Vehicles.....	139,500	165,900	165,900	40,100	37,100	151,400
Total.....	1,235,800	1,565,500	1,560,500	412,200	406,500	1,644,700

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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1977 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT

SPACE SHUTTLE PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Orbiter	634,757	877,300	871,200	230,900	226,000	842,500
Main engine	95,300	135,500	135,500	36,000	36,000	193,800
Solid rocket booster	21,143	76,200	69,300	18,000	18,000	82,600
External tank	34,000	66,100	77,200	15,100	17,100	64,000
Launch and landing	12,300	50,900	52,800	21,000	23,900	105,200
Total	797,500	1,206,000	1,206,000	321,000	321,000	1,288,100
Distribution of Program Amount by Installation:						
Johnson Space Center	625,260	864,948	854,294	227,265	218,200	814,500
Kennedy Space Center	12,300	50,900	52,800	21,000	23,900	105,200
Marshall Space Flight Center	151,898	278,400	284,200	69,200	75,200	353,200
National Space Technology Laboratories	345	1,900	2,800	500	700	4,200
Goddard Space Flight Center	68	100	189	25	---	---
Ames Research Center	---	---	760	---	---	---
Flight Research Center	---	---	714	---	---	---
Langley Research Center	28	52	341	10	---	---
Headquarters	7,601	9,700	9,902	3,000	3,000	11,000
Total	797,500	1,206,000	1,206,000	321,000	321,000	1,288,100

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1977 ESTIMATES

OFFICE OF SPACE FLIGHT

SPACE SHUTTLE PROGRAM

SCHEDULE

PROGRAM	MISSION	CALENDAR YEAR
Space Shuttle	Rollout of Orbiter No. 1	September 1976
	First Approach and Landing Test	4th Quarter 1977
	First Manned Orbital Flight	Mid-1979
	Developmental Flights	3rd Quarter 1979 - Mid-1980
	Initial Shuttle Operational Capability	Mid-1980

OFFICE OF 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 round-trip access to space beginning in the 1980's. The Shuttle will be the first reusable space vehicle and will be configured to carry many different types of payloads to and from low earth orbit. Its development will provide economical space operations for earth applications, scientific, defense and technological payloads. The Shuttle is, however, much more than just a transportation vehicle. It will offer unique capabilities that cannot be achieved with today's expendable launch vehicles -- to retrieve payloads from orbit for reuse; to service and repair satellites in space; to transport to orbit, operate, and return space laboratories; and to perform rescue missions. These capabilities will result in savings in the cost of space operations, while greatly enhancing the flexibility and productivity of the missions.

The Space Shuttle consists of four basic flight hardware elements -- the orbiter, the main engines, an external propellant tank and twin solid rocket boosters -- and the launch and landing systems. The orbiter is the reusable spacecraft portion of the Space Shuttle system. Its large payload volume of 285 cubic meters (370 cubic yards) and cargo carrying capacity of up to 29,500 kilograms (65,000 pounds) will permit payloads to be built to less restrictive design requirements. The orbiter vehicle will carry personnel and payloads to orbit to perform their assigned tasks and return them to earth. The orbiter is roughly the size of a DC-9 aircraft and will be powered by three liquid fueled reusable main engines. The reusable orbiter will serve both as a space vehicle and, during the return to earth phase, as an aircraft. It can provide a habitable environment for the crew, including scientists and engineers, for missions up to thirty days in duration.

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 45 kilometers (km) (25 nautical miles), the solid rocket boosters burn out, are separated and descend by parachute to a soft splashdown in the ocean about 295 km (160 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 before 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, aided by orbital maneuvering engines, will enter earth orbit to perform its mission. After completing its mission, the orbiter will again fire its orbital maneuvering engines to deorbit and re-enter the atmosphere at a high angle (about 34°) in a shallow flight path to minimize the frictional heating. At 21 km (about 70,000 feet) altitude, the orbiter will begin 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 typical operations, the Shuttle can carry up to seven people, including the flight crew, for periods up to seven days. They will experience forces no greater than three times that of gravity (3-g forces) during launch and landing and will be able to perform their work in shirt-sleeve comfort.

STATUS:

Space Shuttle development is well underway and is in the period of peak development and testing, leading to the planned achievement of the first approach and landing test in late 1977 and the first manned orbital flight in mid-1979. All major Shuttle system elements are under contract and development is proceeding as planned. Many components of the Shuttle system were completed in FY 1975 and others are being completed during FY 1976 as fabrication, assembly and testing continue to progress. Funding for FY 1977 will permit Shuttle prime contractors and subcontractors to continue the manufacturing and testing of the four basic flight hardware elements of the Space Shuttle and the development of the launch and landing systems for the Shuttle.

During FY 1976, structural elements of Orbiter No. 1 are being completed and delivered to the assembly plant in Palmdale, California. By the end of the fiscal year, assembly operations for this first orbiter will be essentially completed, with rollout scheduled for September 1976 - the end of the Transition Quarter. Orbiter No. 1 will be used for the approach and landing tests, beginning in 1977. Work has also been initiated on fabrication of parts for Orbiter No. 2, which will be used for the First Manned Orbital Flight in 1979. Major structures, such as the mid fuselage, wings and vertical stabilizer for Orbiter No. 2 will be shipped from the subcontractors during FY 1977 for assembly at Palmdale, California. Main engine component and integrated subsystem test firings are underway and will continue through FY 1976 and the Transition Quarter.

FY 1977 funding will support the first captive flight, with Orbiter No. 1 mated to the carrier aircraft, in the first half of 1977 and the first approach and landing flight in late 1977. These flights will verify the orbiter's aerodynamic characteristics and approach and landing capability. The main propulsion

test article components will be completed and delivered to the National Space Technology Laboratories (NSTL) for preparations leading to test firings in FY 1978. These tests are conducted to verify the orbiter's main propulsion system performance at sea level. The main propulsion test article for the external tank will be delivered in FY 1977 and the tank structural test articles will be delivered in early 1978. The development firing test program for the solid rocket motors will be initiated in the second half of 1977. Delivery of the initial mini-computers and peripheral devices for the launch processing system to the Kennedy Space Center is also scheduled for FY 1977.

CHANGES FROM BUDGET ESTIMATES:

The current estimates for the Space Shuttle program are the same as the budget estimates for FY 1976 and the Transition Quarter. The funding adjustments among the Shuttle project elements reflect decreases in the orbiter and solid rocket booster projects resulting primarily from prime contract negotiations, offset by increases in the requirements for the external tank and launch and landing systems development. These adjustment are addressed under the appropriate project element.

BASIS OF FUND REQUIREMENTS:

Orbiter

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Orbiter.....	634,757	877,300	871,200	230,900	226,000	842,500

OBJECTIVES AND STATUS:

The orbiter will be a fully reusable vehicle with a capability for multipurpose low earth orbital operations. Its payload bay will measure 18.3 meters (60 feet) in length and will have a diameter of 4.6 meters (15 feet). The orbiter with its twin solid rocket boosters will be capable ot placing 29,500 kilograms (65,000 pounds) into a 185 kilometer (100 nautical miles) circular orbit, due east launch azimuth.

In FY 1976, the orbiter prime contractor, the Rockwell International/Space Division, Downey, California, will complete design, fabrication and major assembly of Orbiter No. 1. Rollout of Orbiter No. 1 is scheduled for September 1976. This orbiter is being configured for the first approach and landing test

which will be conducted in late 1977 at the Flight Research Center, Edwards, California. Orbiter No. 2 is in the manufacturing stage. During 1977 the subcontractors for the mid-section, wings, vertical stabilizer, cargo bay doors, landing gear, nose section and leading edges are scheduled to ship these elements to Palmdale, California for installation. Orbiter No. 2 will be configured for the first manned orbital flight, which is to be launched from the Kennedy Space Center in 1979.

A Critical Design Review to verify compliance with the system and technical requirements for those systems required for the Shuttle approach and landing tests will be conducted in 1976. Ground support equipment and the test station at Palmdale, California, will be completed by the end of FY 1976 and ready for use in the checkout of Orbiter No. 1. In addition, development tests to support preparation for the first approach and landing tests will be conducted at the Flight Control Hydraulic Laboratory in Downey, California.

The orbiter structural test article fabrication is being initiated during FY 1976 and the quarter scale ground vibration test model will be delivered to Downey, California. The orbiter main propulsion test article will be completed and delivered to the National Space Technology Laboratories for the propulsion system test program. Both the aft pod and engine of the orbital maneuvering subsystem will be completed and delivered to the White Sands Test Facility in New Mexico.

During FY 1976, major milestones on the thermal protection system for the orbiter will be achieved, including material characterization of both the low and high temperature reusable surface insulation. Development testing of representative pieces of the high temperature reusable surface insulation and reusable carbon-carbon for the leading edges and the nose will be subjected to repeated re-entry heating and environmental testing. The thermal protection facility is being activated and checked out during this period to support thermal protection system tile deliveries in the second half of 1976.

Efforts toward completion and installation of the avionics hardware systems for Orbiter No. 1 are proceeding in FY 1976. These systems are guidance and navigation, flight control, communications, display and control, instrumentation, data processing and electrical power distribution. In addition, efforts on the guidance and navigation hardware systems for Orbiter No. 2 will be underway and delivery of system components will be initiated in late 1976. Qualification of the communication and tracking system for Orbiter No. 1 will be completed to support the first approach and landing test in 1977. Software will continue to be developed and tested at the Johnson Space Center and integrated with the avionics hardware systems for validation in the Center's Shuttle Avionics Integration Laboratory (SAIL).

In addition, the orbiter activities provide for project support efforts managed by the Johnson Space Center. These efforts include acquiring and developing simulators, Shuttle training aircraft and the carrier aircraft, as well as supplying government furnished equipment, such as space suits, and performing many tests and studies required to support the orbiter project.

CHANGES FROM FY 1976 AND TRANSITION QUARTER BUDGET ESTIMATES:

Orbiter funding for FY 1976 and the Transition Quarter was reduced by a total of $11.0 million. This adjustment reflects revised phasing of funding requirements resulting from the Design, Development, Test and Evaluation (DDT&E) Increment II contract negotiated with Rockwell International in September 1975.

BASIS OF FY 1977 ESTIMATES:

In FY 1977, after rollout of the first orbiter, final checkout will be completed in preparation for the approach and landing test program. The first captive flight with the orbiter mated to the 747 carrier aircraft will occur in the first half of 1977. The first approach and landing test (ALT) flight will take place in late 1977. This ALT program will verify the low speed aerodynamic characteristics of the aircraft, the avionics and communications systems, flight controls, and other subsystems involved in the final flight phase.

The critical design review of the thermal protection system (TPS) will be held in early FY 1977. Testing will continue during FY 1977 on the various TPS applications such as the carbon-carbon material for the leading edge and thermal gap protection seals. Fabrication of components of the TPS system for the first orbital flight vehicle (Orbiter No. 2) will be initiated. This effort includes the reusable tiles and leading edge material, as well as the flexible, reusable surface insulation (nomex felt) blanket for the lowest temperature regions, which are located on top of the orbiter and the payload bay doors.

During 1977, major structural components for Orbiter No. 2, such as the wings, mid-fuselage, forward fuselage, payload bay doors, aft fuselage and vertical stabilizer, will be delivered to Palmdale, California for initial systems installation and final assembly.

Assembly and subsystems installation of the vibro-acoustic test article will begin in FY 1977. The airframe structural test article set-up will also be completed at Palmdale, California. The one-quarter scale ground vibration test model will be delivered to the Downey test facility and testing will be initiated. The orbiter main propulsion test article will be completed and delivered to the National Space Technology Laboratories for the propulsion system test program. During FY 1977, the orbital maneuvering subsystem will be installed in the test stands at the White Sands Test Facility to support the start of testing in 1978. Testing and qualification of the auxiliary power unit will proceed during FY 1977.

The various avionics systems are areas of major importance in FY 1977. Emphasis will be placed on hardware and software certification, installation and checkout for the approach and landing tests (ALT). Hardware and software testing and qualification for orbital flight testing will also proceed. The avionics hardware/software required in Orbiter No. 1 for ALT will undergo certification tests in the Shuttle Avionics Integration Laboratory at the Johnson Space Center in late FY 1977.

Main Engine

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Main engine.....	95,300	135,500	135,500	36,000	36,000	193,800

OBJECTIVES AND STATUS:

The Space Shuttle orbiter will use three high pressure liquid hydrogen/oxygen engines, each with a 2,100,000-newton (470,000-pound) vacuum thrust level. The Space Shuttle main engine (SSME) represents a major advance in propulsion technology and incorporates maximum utilization of existing technologies. In addition, it has the advantage of a much longer operating life. It will be the first large liquid fuel rocket engine designed to be reusable and to require minimum maintenance between flights. An engine-mounted controller will be used to ensure operation within the limits of the high temperatures and pressures in the combustion cycle. Performance will be increased by using a two-stage combustion process with a high expansion ratio nozzle, which results in more efficient engine operations without increasing the size.

In FY 1976, the prime contractor, Rocketdyne Division of Rockwell International, is conducting testing and fabrication of the major subsystems of the Space Shuttle main engines. Components tested at Santa Susana, California, include the ignition system, thrust chambers, fuel and oxidizer turbopumps and the preburners. Continued testing of these components is scheduled through FY 1977. Engine firings conducted at the National Space Technology Laboratories in mid-FY 1976 attained 37 percent of the required power. These tests will be followed by throttling tests over the full power level spectrum. Fabrication of the main propulsion test article to support the main propulsion test activity scheduled for early FY 1978 is also continuing. Long-lead time procurement of materials and hardware for the flight engines is being initiated in FY 1976 to support the start of manufacturing in FY 1977.

In addition, the main engine activities provide for necessary project support efforts. These efforts include the procurement of propellants for test firing the engine and its components; the maintenance of the engine systems hardware simulation laboratory; logistics support; evaluation of materials and processes; and support for the design, fabrication, test and analysis of the controller. A key area is the testing of the 188,000-newton (42,000 pound) thrust model combustion chamber, which is providing valuable data on engine life. Detailed tests and analyses for this engine are being conducted during FY 1976 and will continue in FY 1977.

BASIS OF FY 1977 ESTIMATES:

FY 1977 funding requirements for the main engine development provide for intensive test activity. Engine component testing will continue at Santa Susana on such components as the fuel and oxidizer preburners, ignition subsystem, main combustion chamber and the high and low pressure turbopumps. Testing of these components will be conducted at operational power levels to demonstrate their performance and reliability characteristics. Concurrent with component testing at Santa Susana, testing of flight configured engines will be conducted at the National Space Technology Laboratories (NSTL) to demonstrate the throttling capability of the main engine throughout the power level spectrum.

In late FY 1977, a set of three main propulsion test engines will be delivered to NSTL. They will be installed and combined with the orbiter and external tank test articles for testing of the Space Shuttle main propulsion system scheduled to begin in early FY 1978. Fabrication of components for the flight engines to be used in Orbiter No. 2 will also be initiated.

Project support tasks continuing at the Marshall Space Flight Center will include maintaining the engine systems hardware simulation laboratory to conduct control system and dynamic operations testing, engine software integration support activities and in-house assessments of engine controller components. In addition, project support funding provides for main engine propellant procurements required for the test programs at both NSTL and Santa Susana.

Solid Rocket Boosters

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Solid rocket boosters.....	21,143	76,200	69,300	18,000	18,000	82,600

OBJECTIVES AND STATUS:

The Space Shuttle propulsion system includes two reusable solid rocket boosters (SRB) which burn in parallel with the orbiter main engines to provide the necessary thrust from lift-off to booster staging. These boosters are approximately 3.6 meters (12.2 feet) in diameter and 45.5 meters (149 feet) long. Each booster delivers approximately 11.6 million newtons (2.6 million pounds) average vacuum thrust. The boosters are attached to the external tank and at staging, about 45 kilometers (150,000 feet), separate from the orbiter and external tank. The SRBs will descend by parachutes and land in the ocean about 295 kilometers (160 nautical miles) from the launch site. They will then be recovered by ship and returned for refurbishment and reuse.

The main element in the solid rocket booster system is the Solid Rocket Motor (SRM), which is being developed by Thiokol, Wasatch Division, Utah. The other booster system elements, such as the recovery system, thrust vector control, attach structures, forward and aft skirt, and separation motors, have been or 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 1976, fabrication of the development motors is being conducted to support the first test firings in FY 1977. Subcontractors are proceeding with manufacture, heat treatment and machining of the solid rocket motor cases. A prototype flexible bearing for the thrust vector control system is also being fabricated and testing will be initiated during FY 1976. Hardware fabrication for the separation motors and fabrication of major structural components are underway.

In addition, current efforts include solid rocket motor ballistic performance analysis, development of a computer program to measure the stress in the solid rocket propellant and dynamic analysis of solid rocket booster structures. These support tasks will continue through FY 1977.

CHANGES FROM BUDGET ESTIMATES:

Solid rocket booster funding for FY 1976 was reduced by $6.9 million. There was no change in the Transition Quarter estimate. The FY 1976 adjustment reflects revised phasing of funding requirements resulting from negotiation of the Thiokol contract and minor rephasing of funding for booster subsystems, such as the separation motor and the thrust vector control system.

BASIS OF FY 1977 ESTIMATES:

Commencing in FY 1977, delivery of the first solid rocket motor development cases will be made by the case subcontractor (Rohr, located at Chula Vista, California) to Thiokol for propellant loading. This effort will be followed by the first development motor firing in late FY 1977. The first development nozzle will also be delivered during FY 1977. The manufacture of the motor cases for the first manned orbital flight will be initiated, leading to delivery to Thiokol in FY 1978.

Preliminary design of the recovery system will be completed in FY 1977, and tests and evaluation will be initiated. In addition, the recovery system hardware and a structural test article will be delivered to the Marshall Space Flight Center. Prototype parts will be fabricated, tested and delivered during FY 1977 and flight article parts fabrication will be continued. Drop tests will also be conducted with prototype equipment.

In FY 1977, a critical design review of the complete Solid Rocket Booster is planned to verify compliance with the system and technical requirements. Hardware for electrical testing will be delivered during this period and design, fabrication and testing of the thrust vector control (TVC) components will progress. Test units of the TVC will also be delivered to the Marshall Space Flight Center. Fabrication and delivery of the TVC components as well as assembly activities will continue.

During FY 1977, the booster assembly contractor, to be selected during 1976, will continue the tasks necessary to perform future launch support work. These efforts will entail booster assembly logistics and operations planning, design of assembly and checkout operations, and support to the launch site operations. These tasks are necessary to optimize the flow and efficiency of the assembly operations at the launch site.

External Tank

	1975	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
			(Thousands of Dollars)			
External tank.....	34,000	66,100	77,200	15,100	17,100	64,000

OBJECTIVES AND STATUS:

The external tank contains all the propellants for the orbiter main engines - liquid hydrogen as the fuel and liquid oxygen as the oxidizer. The liquid propellants are consumed by the main engines of the orbiter from lift-off to main engine cut-off, which occurs just before orbital insertion. Following this main engine cut-off, the external tank will be separated from the orbiter and will tumble through a ballistic trajectory to impact within a designated remote ocean area. The external tank is a single assembly approximately 8.5 meters (27.5 feet) in diameter, and 47 meters (154 feet) long. The external tank will contain approximately 700,000 kilograms (1.55 million pounds) of propellant at lift-off. The liquid hydrogen volume is 1,530 cubic meters (54,000 cubic feet) and the liquid oxygen volume is approximately 565 cubic meters (20,000 cubic feet).

The Martin Marietta Corporation, Denver Division, is the design and development contractor for the external tank. Development and fabrication will take place in the government-owned Michoud Assembly Facility near New Orleans, Louisiana. Initial tooling is being installed for the manufacturing operations.

The external tank is the only expendable element in the Space Shuttle system and every effort is being made to reduce the unit cost to a minimum. The prime contractor's design has emphasized commonality of configuration between the tank elements in order to utilize the same tooling for the oxygen and hydrogen

tanks where feasible. Low cost production techniques and materials and processes are being employed while maintaining safety and reliability. Six large tools are common to the fabrication of domes and barrel sections for both of the propellant tanks. Extremely light weight one-inch thick foam insulation will be applied to the outer surface of the external tank by an automated spray process.

In FY 1976, the prime contractor conducted a critical design review of the external tank. Fabrication and assembly of the structural test articles (the intertank, the liquid oxygen and liquid hydrogen tanks) is starting in FY 1976, leading to delivery of the first test article to the Marshall Space Flight Center testing facilities in FY 1977.

Other major activities in FY 1976 include fabrication of the main propulsion test article tank and main propulsion test article integration for testing with the orbiter aft fuselage and the three propulsion test engines at the National Space Technology Laboratories (NSTL). Welding facilities and equipment were completed and installed at Michoud in the first half of FY 1976. In addition, long lead time procurement of selected materials for the first increment of flight tanks is continuing in FY 1976. Tooling required for the fabrication and assembly of the flight tanks is being completed and verification will be completed before the start of fabrication in FY 1977.

In addition, the external tank activities provide for necessary project support efforts. These efforts support 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.

CHANGES FROM FY 1976 AND TRANSITION QUARTER ESTIMATES:

External tank funding for FY 1976 and the Transition Quarter was increased by a total of $13.1 million. This increase is primarily associated with three areas: (1) increased effort to complete the critical design review (completed November 1975); (2) replacing the original thermal protection material with high temperature spray-on foam insulation and; (3) a change in material for the intertank structure.

BASIS OF FY 1977 ESTIMATES:

During FY 1977, component fabrication and assembly for the external tank for the first manned orbital flight will continue. In addition, fabrication of the first and second flight tanks will be initiated. In late 1977, the external tank test article for the main propulsion test will be delivered to the National Space Technology Laboratories. Assembly and checkout of the structural test articles will be completed and deliveries will be made to the Marshall Space Flight Center in early FY 1978. Ground support and test equipment final design release will also occur in FY 1977.

Assembly and checkout of the test articles required for the ground vibration test program will be performed during FY 1977, leading to delivery to MSFC for testing in 1978. FY 1977 funding will also provide for the continuation of the activation of the structural test facilities at the Marshall Space Flight Center and the initiation of the external tank structural test program.

Launch and Landing

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Launch and landing.....	12,300	50,900	52,800	21,000	23,900	105,200

OBJECTIVES AND STATUS:

To meet requirements for Shuttle ground operations, including turnaround times, launch rates and cost objectives, new launch processing techniques and equipment must be developed. In response to this need, a launch processing system (LPS) is being designed, developed and implemented at the Kennedy Space Center (KSC). The LPS will consist of two major elements: the checkout, control and monitor subsystem (CCMS) and the central data subsystem (CDS). The CCMS will make maximum use of a decentralized computer processing network. Consoles, each containing a small computer, will perform within assigned subsystem control functions. The CDS will provide support to the CCMS and will be comprised of two large scale computers (primary and secondary) with shared mass storage devices, related communications processors and interface and peripheral devices.

In FY 1976, design efforts on the launch processing system are continuing, leading to a critical design review to determine system operational capability. Major activities in FY 1976 include systems engineering and integration, programming of computers and program validation. Procurement was initiated in FY 1976 for software, mini-computers for the checkout, control and monitor subsystem, line printers, readers and consoles. Some of this equipment will be delivered during FY 1976. Procurement activity for major components of the CDS large scale computers is also being initiated.

In addition, the launch and landing activities provide for necessary project support efforts. These efforts include: the design, procurement and installation of unique ground support equipment (GSE) for the approach and landing tests; GSE to support the first manned orbital flight; systems engineering and integration support between these ground support systems and other identified Space Shuttle operational areas; establishment of an engineering documentation center; and technical analyses.

CHANGES FROM FY 1976 AND TRANSITION QUARTER ESTIMATES:

Launch and landing funding requirements for FY 1976 and the Transition Quarter increased by a total of $4.8 million. This increase is associated with the negotiation of two fixed price contracts in the launch processing system, resulting in higher early year funding with offsetting reductions in later years.

BASIS OF FY 1977 ESTIMATES:

During FY 1977, major efforts will be concentrated on the launch processing system (LPS) engineering and integration activities. System definition will be completed and integration of the LPS will be initiated. Systems engineering and software development support will also continue throughout FY 1977, and mini-computers and peripheral devices will be delivered and installed at the Kennedy Space Center. The first hardware acceptance of the checkout, control and monitor equipment is planned during FY 1977. Major portions of the central data system will also be installed and checked out at the Kennedy Space Center. During FY 1977, installation of LPS components will commence at the Shuttle Avionics Integration Laboratory at the Johnson Space Center to support overall Shuttle system testing.

In FY 1977 the design engineering efforts, supported by systems analyses and other engineering studies, on major ground support equipment (GSE) items required for launch, landing and turnaround operations at the Kennedy Space Center will be at a peak level. The initial deliveries of GSE will also take place. Deliveries will include launch systems hardware elements, such as the solid rocket booster support equipment for the mobile launcher and the payload ground handling mechanism for the launch pad.

Activities of the prime Shuttle element suppliers at KSC will be increased during FY 1977 and will be directed toward the checkout, maintenance, integration, and launch support requirements for the Shuttle. These efforts will also cover the planning and activation of Shuttle ground support equipment for each element.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1977 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT

SPACE FLIGHT OPERATIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Space transportation system operations capability development	3,000	9,500	9,500	2,600	2,000	17,300
Development, test and mission operations	170,200	166,100	161,100	43,200	41,100	169,900
Advanced programs	16,000	18,000	18,000	5,300	5,300	18,000
Apollo Soyuz Test Project	109,600	---	---	---	---	---
Total	298,800	193,600	188,600	51,100	48,400	205,200
Distribution of Program Amount by Installation:						
Johnson Space Center	115,978	96,750	94,660	25,450	25,203	100,988
Kennedy Space Center	77,320	39,100	38,000	10,250	8,310	42,940
Marshall Space Flight Center	77,067	47,550	45,110	12,475	11,860	51,557
National Space Technology Laboratories	1,089	7,000	7,140	1,800	1,800	7,000
Goddard Space Flight Center	488	340	525	100	200	400
Jet Propulsion Laboratory	651	450	796	250	250	550
Ames Research Center	540	825	484	250	200	365
Langley Research Center	402	235	274	125	200	200
Lewis Research Center	200	250	155	200	100	200
Headquarters	25,065	1,100	1,456	200	277	1,000
Total	298,800	193,600	188,600	51,100	48,400	205,200

OFFICE OF SPACE FLIGHT

SPACE FLIGHT OPERATIONS PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Space Flight Operations program includes Space Transportation System (STS) Operations Capability Development; the common support activities conducted under Development, Test and Mission Operations; and Advanced Programs. The Apollo Soyuz Test Project, which was successfully flown in July, 1975, was also funded within the Space Flight Operations program.

The Space Transportation System (STS) Operations Capability Development includes space transportation system development and support activities other than the Space Shuttle. These development and support activities are necessary to facilitate the planning and orderly transition to STS operations, which will provide the means for expanding our capabilities in space while reducing the cost of operations. The principal areas of activity include the Spacelab, the Interim Upper Stage (IUS), and Multi-use Mission Support Equipment (MMSE).

Development, Test and Mission Operations provide the common engineering, scientific and technical support 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 all Space Flight research and development activities.

Advanced Programs effort concentrates on the necessary planning and integration of payload activities for the space transportation system and provides technical as well as programmatic data for the evaluation of potential future space flight systems. Advanced Programs also investigates the effective future use of new technologies.

All major objectives of the Apollo Soyuz Test Project mission were successfully accomplished. Fiscal Year 1975 was the last year of new obligational authority requirements for this project.

BASIS OF FUND REQUIREMENTS:

Space Transportation System (STS) Operations Capability Development

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Spacelab	2,000	6,100	6,100	1,900	1,300	10,500
Interim Upper Stage	1,000	3,400	3,400	700	700	3,800
Multi-use Mission Support Equipment	---	---	---	---	---	3,000
Total	3,000	9,500	9,500	2,600	2,000	17,300

OBJECTIVES AND STATUS:

The STS Operations Capability Development activity consists of three major areas of effort: Spacelab, Interim Upper Stage (IUS) and Multi-use Mission Support Equipment (MMSE).

Spacelab development falls into two categories--program and operations capability. Program activities support the European Space Agency (ESA) Spacelab development effort with engineering and operations studies in areas such as payload safety and accommodations, operations and logistics. Additional efforts include the development of a crew transfer tunnel and procurement of necessary mockups, trainers and other ground support equipment. The Spacelab operations capability activities include procurement of flight and ground hardware and system activation activities leading to an operational capability.

The Interim Upper Stage (IUS) is an upper stage that will be used to deploy Shuttle-launched payloads to high energy and escape orbits. The U.S. Air Force is responsible for the development of the IUS. NASA has the responsibility to define the non-DoD IUS design and operational requirements that are unique to NASA and other non-DoD missions.

Multi-use Mission Support Equipment (MMSE) consists of ground and flight hardware used for interfaces between the payloads and the space transportation system. This class of hardware will be developed into a standard, reusable inventory for all payloads.

BASIS OF FY 1977 ESTIMATES:

In FY 1977 Spacelab funding will be used to continue studies in support of Spacelab development and operations concepts. The crew transfer tunnel design will be completed and manufacture will be initiated. Funding for procurement of a high fidelity mockup/lg trainer will be completed and procurement of a hardware inventory of Spacelab elements will be initiated.

In conjunction with the USAF Interim Upper Stage design, development, test and evaluation phase in FY 1977, NASA will determine the requirements for NASA-unique items to support non-DoD IUS missions.

FY 1977 funding for Multi-use Mission Support Equipment will provide for initiating development of selected hardware items to support Space Transportation System/payload integration and ground operation activities at the launch and landing site, as well as payload operations in orbit.

Spacelab

1975	1976		Transition Quarter		1977
Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)			
2,000	6,100	6,100	1,900	1,300	10,500

OBJECTIVES AND STATUS:

The Spacelab is a major element of the Space Transportation System (STS). The program is being carried out jointly by NASA and the European Space Agency (ESA) to provide a versatile, reusable space laboratory which will be flown to and from earth orbit in the cargo bay of the Space Shuttle. The Spacelab will consist of a pressurized module and unpressurized pallet segments which can be used in various combinations to support mission requirements. It will permit researchers and scientists to personally conduct a wide range of experiments in a ground-type laboratory while operating in the unique environment of space.

Ten European nations, of which nine are members of the European Space Agency, are participating in the program. NASA and ESA are committed to bear the cost of their respective program responsibilities. ESA funding responsibilities include the design, development, production, and delivery of the first Spacelab and associated ground support equipment to NASA, as well as the capability to produce additional Spacelabs. NASA funding responsibilities include the development of flight and ground support equipment not provided

by ESA, development and conduct of Spacelab operations, and procurement of additional hardware needed to support NASA's missions.

Fiscal Year 1976 and Transition Quarter funds are being used to continue on-going engineering studies defining effective methods of operating the Spacelab system with its variety of payloads and developing efficient, economical techniques for computerized approaches to experiment integration, mission planning and payload operations. Additional engineering studies are being initiated to determine the most economical logistics and ground operations procedures and to minimize onboard contamination which would be detrimental to the scientific objectives of some experiments. Procurement of a high fidelity mockup/lg trainer will be initiated during FY 1976 for use at the Kennedy Space Center in verifying the interfaces with the facilities (e.g., transportation, handling, payload changeout room, and vertical access). This mockup will serve later as a lg crew trainer at the Johnson Space Center, thus eliminating the requirement to procure a separate lg trainer. FY 1976 funds are also being utilized for development of the crew transfer tunnel linking the Spacelab to the Space Shuttle orbiter cabin.

These activities will continue during the Transition Quarter, with the expectation that the definition of hardware and software necessary to operate the Spacelab, and its planned payloads, will be completed.

Concept Verification Testing (CVT) is the ground simulation activity used to plan effective payload utilization and operation of the Spacelab. Through breadboards and simulators, CVT provides the means for the development of effective data management system interfaces for conducting systems simulations, including software, so that the integration of final experiment flight hardware can be designed for effective research and applications at a minimum cost. FY 1976 funding is being used for testing and simulation activities in the CVT General Purpose Laboratory (GPL) and the Data Management System Simulator (DMSS) in support of Spacelab operations capability development, including evaluating the merits of the central data computer compared to the distributive mini computers. FY 1976 funds are also being used to complete the procurement of the Space Ultra-reliable Modular Computer (SUMC) III.

CHANGES FROM BUDGET ESTIMATES:

Transition Quarter Estimate:

Spacelab funding was decreased by $600 thousand as part of the adjustments necessary to accommodate the general Congressional reduction in NASA's R&D budget request for the Transition Quarter.

BASIS OF FY 1977 ESTIMATES:

The FY 1977 Spacelab funding requirements continue to support the European Space Agency's development of the Spacelab through establishing design requirements, including those of the user community; defining the Spacelab's operational environment; developing those hardware elements not provided by ESA, such as the crew transfer tunnel which provides access between the Spacelab and the Space Shuttle orbiter cabin; and developing hardware mockups and trainers.

FY 1977 funding is required to continue studies in the engineering, logistics, operations and interface areas, as well as on-going system studies which involve trade-off studies to determine alternate approaches to hardware processing and flow to minimize the ground support equipment, software and facilities requirements.

FY 1977 funds will also provide for the design and development of hardware. The crew tunnel transfer tunnel design will be completed in FY 1977 and manufacture will be initiated. NASA ground support equipment design and development will also be continued through FY 1977. This includes ground support equipment required to outfit the assembly and checkout stands, racks and pallet assembly stands, and other equipment needed to accommodate the Spacelab processing requirements. Procurement of the hi-fidelity mockup/lg trainer will be completed. Funding will also be used to purchase equipment such as sensors and electronic instrumentation (vertification flight instrumentation) required to verify Spacelab subsystem performance and the induced environment to which payloads will be subjected.

The development of the Spacelab operations capability is a NASA responsibility which includes the procurement of flight hardware; the planning, design, development and verification of facilities; hardware and software required for mission planning; payload integration and crew training; pre-flight checkout; flight operations; post-flight refurbishment; and data pre-processing and distribution. Integration effort associated with the Spacelab operations capability development will be implemented by integration contractors in FY 1977. Funds in FY 1977 will also be used to initiate procurement of the minimum hardware inventory of Spacelab flight elements to support up to twelve missions per year. In addition to initiating hardware procurement from ESA, funds are also required to initiate hardware procurement and system development for a facility to integrate experiment software into the Spacelab computer system. This facility should be in operation when the Spacelab engineering model is delivered to the U.S. by ESA in mid-1978. Timely completion of this integration facility is necessary to provide the approximate two-year lead time required to develop complex system software for the first Spacelab flight scheduled for late 1980. Software development must proceed in parallel with hardware procurement to insure that software verification can be accomplished in a timely manner after the hardware has been installed.

Interim Upper Stage

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
1,000	3,400	3,400	700	700	3,800

OBJECTIVES AND STATUS:

The Interim Upper Stage (IUS) 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. DoD will develop the Interim Upper Stage, which will be a multi-stage, solid propellant expendable vehicle and will be operational in mid-1980. The NASA IUS program objectives are to coordinate NASA-unique and other non-DoD requirements with DoD during the design, development, test and evaluation phase to provide for the definition of the non-DoD design and operational requirements, and to insure IUS operations compatibility with the Space Transportation System and respective ground and flight systems.

NASA is currently coordinating the incorporation of the non-DoD requirements into the DoD IUS program and participating in the planning of the validation phase and development phase activities. NASA activity in FY 1976 includes the definition of mission/payload requirements for non-DoD missions, increased definition of the IUS/Shuttle and ground systems interfaces, identification of NASA-unique hardware and software requirements, and definition of operations concepts.

BASIS OF FY 1977 ESTIMATES:

In FY 1977, NASA will continue to work with the DoD to assure that the Interim Upper Stage meets unique NASA and other non-DoD requirements. NASA will participate in the validation phase and the planning of the subsequent full-scale development phase. NASA funding in FY 1977 will support the definition of the NASA-unique hardware and software. This effort will include system and operations analysis; preliminary design, system specifications, and hardware interface definitions; development of operational planning concepts and support requirements.

Multi-use Mission Support Equipment (MMSE)

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
---	---	---	---	---	3,000

OBJECTIVES AND STATUS:

The Multi-use Mission Support Equipment is a class of ground and flight hardware that provides for the interfaces between the elements of the Space Transportation System and the payloads that will be flown on this system. This economical, reusable, and long life equipment is required to transport, handle, accommodate and operate a wide range of science, applications and technology payloads as this type of ground and flight hardware can be furnished more economically from a standard equipment inventory rather than by individual payload users.

BASIS OF THE FY 1977 ESTIMATES:

To meet the need dates and corresponding hardware development milestones, development of certain Multi-use Mission Support Equipment must be initiated in FY 1977. This effort is required to insure delivery of the hardware to support the STS/payload integration and ground operations activities at the launch and recovery site and to support payload operations in orbit during the initial Shuttle operational flights. These initial MMSE items include an inter-site payload transportation and handling system, payload specialist station equipment, and a trace contamination analyzer system.

The inter-site payload transportation and handling system will satisfy the needs of the payload developers and integrators for handling and transporting payloads at their sites and moving these cross-country to and from the Space Transportation System launch and recovery sites. A canister and transporter, whose outside dimensions will be compatible with most road restrictions and available air carriers, will form the nucleus of the system. Auxiliary equipment for handling and environmentally conditioning the payload inside the canister will be a characteristic of the canister.

FY 1977 funds will provide for the development of the payload specialist station equipment which is an integrated command and data management capability to operate experiments located in the orbiter cargo bay. This equipment will be designed for installation in the aft flight deck. Use of Spacelab payload specialist station equipment to satisfy upper stage and free flyer requirements will be emphasized to allow development of permanently installed equipment.

FY 1977 funds will also provide for the development of a trace contamination analyzer system which will perform in-flight monitoring of aggregate offgasing constituents from payloads, metabolic sources and Spacelab systems. Its primary subsystems consist of a gas chromatograph to detect the presence of atmospheric substances and a mass spectrometer to measure the concentration of each of the atmospheric constituents. Installation of the analyzer in the Spacelab pressurized module will allow relaxation of the material requirements for experiment hardware to be mounted in the Spacelab. Use of the analyzer to meet the Space Transportation System safety requirements will lead to savings in experiment development effort.

Development, Test and Mission Operations

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Research and test operations.....	51,040	55,400	47,400	14,500	12,700	51,300
Data systems and flight operations.....	41,100	40,000	45,200	10,400	11,900	45,900
Operations support.....	49,579	44,300	42,100	11,500	9,700	41,700
Launch systems operations.....	28,481	26,400	26,400	6,800	6,800	31,000
Total.....	170,200	166,100	161,100	43,200	41,100	169,900

OBJECTIVES AND STATUS:

Development, Test and Mission Operations (DTMO) provides the common engineering, scientific and technical support required to conduct ongoing and proposed 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. DTMO functions include research and test operations, data systems and flight operations, operations support, and launch systems operations. These common support efforts are necessary to provide early project definition, including conceptual design, project specifications, and research and technology; to assure engineering support for in-depth technical examination of work performed by prime and major subcontractors on space flight systems; to provide common support equipment and supplies; and to perform backup design, testing and analysis in high technology areas.

It is expected that future DTMO funding requirements will gradually decrease as the transition is made to Space Transportation Systems (STS) operations. At that time, STS operational support activities, direct and indirect, will be funded under STS operations and only support of development efforts will be funded within DTMO.

CHANGES FROM BUDGET ESTIMATE:

The decrease in both FY 1976 and the Transition Quarter budget estimates for Development, Test and Mission Operations is the result of Congressional action reducing the request. Based on Authorization Committee action, the FY 1976 DTMO funding level was reduced by $5.0 million. In addition, the Transition Quarter funding level was decreased by $2.1 million as part of the adjustments necessary to absorb the Congressional cut of $30 million in NASA's R&D budget request for this period.

BASIS OF FY 1977 ESTIMATES:

FY 1977 DTMO funding requirements provide for the common engineering, scientific and technical support required for all Space Flight programs. This support is required for activities conducted under Space Shuttle, Spacelab, the Interim Upper Stage, and Advanced Programs. The FY 1977 Development, Test and Mission Operations funding also provides for support contractor personnel who are an essential part of NASA's in-house capability and are required to pursue ongoing and planned Space Flight efforts.

Research and Test Operations

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
51,040	55,400	47,400	14,500	12,700	51,300

OBJECTIVES AND STATUS:

Research and test operations support a broad spectrum of technical, engineering, scientific, reliability and quality assurance, and safety operations. These activities complement the work of the major development contractors who are spread across the country in contractor-owned facilities and government plants.

CHANGES FROM BUDGET ESTIMATES:

The Research and Test Operations funding was reduced by $8.0 million in FY 1976 and by $1.8 million in the Transition Quarter. The FY 1976 reduction was made to absorb part of the Authorization Committee action which reduced the FY 1976 request. In addition, a reduction resulted from a rephasing of funds to support additional requirements in Data Systems and Flight Operations. The Transition Quarter funding level was decreased as part of the adjustments necessary to absorb the Congressional cut of $30 million in NASA's R&D budget request for this period.

BASIS OF FY 1977 ESTIMATES:

During FY 1977 research and test operations will support critical Space Shuttle activities; efforts complementing the European Spacelab development; preliminary IUS design; and other research and development activities in advanced programs. Effort in this area will increase over FY 1976 in order to keep pace with Shuttle development.

Engineering and test support is provided to assure fulfillment of technical goals as they relate to each program. Examples of FY 1977 Space Shuttle support to be provided at the Johnson Space Center include: (1) conducting the test and evaluation of the Ku-band steerable antenna and performance testing of full scale antenna patterns on the Shuttle antenna; (2) performing interface studies utilizing Orbiter mockups and manipulator development facilities; (3) bringing the crew station mockup to operational status in support of the Shuttle Orbital Flight Test (OFT)/critical design review (4) completing Shuttle Avionics Integration Lab (SAIL) testing for Approach and Landing Test (ALT) avionics verification, supporting the ALT flight test program, and reconfiguring SAIL for OFT avionics certification program; and (5) conducting facility checkout tests in preparation for Orbiter aft fuselage vibroacoustic testing.

At the Marshall Space Flight Center, FY 1977 funding provides for: (1) support to the Shuttle mated vertical ground vibration test, (2) engineering support for the design and development of electromechanical control hardware and control systems for the Shuttle main engine by performing the necessary analysis, review, and coordination; (3) services necessary to determine the structural integrity of the structural test article for the external tank, the model characteristics of the liquid oxygen tank, and to support external tank related work in the ground vehicle test and the main propulsion test programs; and (4) systems requirements and analysis, documentation and configuration management, quality, reliability and systems safety, ground support equipment systems and systems test planning, and methods of contamination control in support of the Spacelab program.

In addition, FY 1977 research and test operations funds which are to be provided to the Johnson Space Center and the Marshall Space Flight Center will support Space Shuttle design reviews, certification testing inspections, tests, configuration control panels, and integration efforts.

Data Systems and Flight Operations

1975	1976		Transition Quarter		1977
	Budget	Current	Budget	Current	Budget
Actual	Estimate	Estimate	Estimate	Estimate	Estimate
		(Thousands of Dollars)			
41,100	40,000	45,200	10,400	11,900	45,900

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OBJECTIVES AND STATUS:

Data systems and flight operations include 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), as well as for the operation and maintenance of the facilities during preparation 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 and validation and flight crew training, as well as the operation of the JSC Central Data Computation Facility and Special Purpose Data System which are required to support Center-wide activities in mission analysis, systems engineering, development, and test functions for the Shuttle program.

Spacecraft and aircraft operations provide for the development of Shuttle flight control, recovery plans and procedures, production of flight plans, flight data files, crew procedures and other elements of data management.

CHANGES FROM BUDGET ESTIMATES:

An adjustment to the FY 1976 estimate was required to initiate the reconfiguration of the Mission Control Center and the Real Time Computer Complex to accommodate Shuttle program requirements. Planning and design effort for the required changes has been intensified resulting in an increase of $5.2 million for systems and flight operations in FY 1976 from the amount previously requested. Projected requirements in the Transition Quarter are $1.5 million higher due to the need to begin long lead procurement of hardware to support the Mission Control Center and the Real Time Computer Complex modifications.

BASIS OF FY 1977 ESTIMATES:

FY 1977 funding in ground-based flight data systems will support the update of the Mission Control Center and the Real Time Computer Complex to provide the flight support and flight data management functions for the Approach and Landing Test (ALT) and Orbital Flight Test (OFT) missions for the Space Shuttle program. This effort will also include the operation of the software development laboratory (SDL, comprised primarily of existing RTCC systems) which is used to develop and validate the Shuttle orbiter flight software, as well as support to equipment and software changes.

FY 1977 efforts in flight simulation and development data systems will increase principally in support of the installation and operation of the new Shuttle simulator hardware. Mission and systems design and performance studies for the Shuttle will also be underway. In addition, ASTP flight data processing support will continue until this effort is completed at the end of FY 1977.

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Spacecraft and aircraft operations activities which will be supported in FY 1977 will include modification, and engineering support services relating to the T-38 space flight readiness training aircraft and the KC-135 zero-G aircraft. Support requirements in FY 1977 will increase in this area with the activation of the T-38 chase aircraft in late FY 1976. Also required in FY 1977 is the flight control, crew training, and engineering support of flight operations planning control for the Approach and Landing Test and the Orbital Flight Test programs.

Operations Support

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
49,579	44,300	42,100	11,500	9,700	41,700

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. It also provides for these technical services for Johnson Space Center's off-site operations at the White Sands Test Facility and the Marshall Space Flight Center's off-site operations at the Michoud Assembly Facility and the Slidell Computer Complex.

CHANGES FROM BUDGET ESTIMATES:

The Operations Support funding was reduced by $2.2 million in FY 1976 and by $1.8 million in the Transition Quarter. The FY 1976 reduction was made to absorb part of the Authorization Committee action which reduced the FY 1976 request. The Transition Quarter funding level was decreased as part of the adjustments necessary to absorb the Congressional cut of $30 million in NASA's R&D budget request for this period.

BASIS OF FY 1977 ESTIMATES:

Fiscal Year 1977 funding will provide for the maintenance of highly technical facilities and equipment, facility refurbishment and renovation, chemical cleaning, engineering design, technical documentation and analyses, telecommunications, component fabrication and logistic support.

A cross section of specific services to be provided in FY 1977 includes: (1) cleaning of hoses, gauges, tubing, and related flight items that are fabricated in-house; (2) operation of shops to do metal furbishing, anodizing, plating, stripping, and etching of selected items of in-house fabricated flight hardware; (3) operation and maintenance of specialized electrical and cryogenic systems, and maintenance of test area cranes; (4) engineering, installation, operation and maintenance of closed circuit fixed and mobile television required for support and/or surveillance of tests; (5) photographic services including still and motion picture processing and audio visual mission support; (6) fabrication of models, breadboards, and selected items of flight hardware; (7) technical documentation services, telecommunications, and graphics; (8) technical services in support of Center operations including receipt, storage, issue of research and development supplies and equipment, and transportation services; and (9) management services in support of Center operations, including data management, microfilming and distribution of technical documentation.

Fiscal Year 1977 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 the basic level of operation and maintenance of the Michoud Assembly Facility where the external tanks for the Shuttle will be fabricated and assembled.

In addition, the FY 1977 operations support funds will provide the basic level of support to the National Space Technology Laboratories which is engaged in the static test firing of the Space Shuttle main engine, integrated component testing of the Space Shuttle main engine and the qualification of the main propulsion test article.

Launch Systems Operations

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
28,481	26,400	26,400	6,800	6,800	31,000

OBJECTIVES AND STATUS:

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

BASIS OF FY 1977 ESTIMATES:

DTMO requirements at the Kennedy Space Center will increase beginning in FY 1977 to support preparation of its launch facilities to accommodate the first manned orbital flight in 1979. FY 1977 activities will support the reconfiguration and preparation of the Center's launch facilities and systems, including the installation of newly designed ground support systems to accommodate the Space Shuttle flight hardware and payload systems.

Fiscal Year 1977 funding provides for mechanical ground system activities involving operations and maintenance of launch systems and facilities as they are activated for Shuttle; support for development testing of Kennedy Space Center designed Shuttle ground support equipment in the Launch Equipment Test Facility (LETF); preservation, maintenance, and operation of Kennedy Space Center electrical and mechanical utilities systems; and operation of technical shops which support maintenance activities.

Fiscal Year 1977 funding will also provide 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. These activities will include operations and maintenance of communication, computational and instrumentation systems as they are activated for Shuttle and instrumentation and measurement support for development testing of Kennedy Space Center designed Shuttle ground support equipment in the Launch Equipment Test Facility (LETF).

Advanced Programs

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Payload integration and mission analysis	5,000	6,000	6,000	1,800	1,800	5,000
Advanced systems	11,000	12,000	12,000	3,500	3,500	13,000
Total	16,000	18,000	18,000	5,300	5,300	18,000

OBJECTIVES AND STATUS:

Advanced Programs consists of two distinct areas of effort: Payload Integration and Mission Analysis and Advanced Systems.

Activities under Payload Integration and Mission Analysis will concentrate on assuring that the use of the Space Transportation System (STS) will be conducted in the most effective and economical manner and that payloads and the STS elements will be operationally compatible.

Advanced Systems activities explore the future direction and opportunities for the nation's space transportation and operations systems. New space transportation concepts, future missions, and operations in space are studied. Selected hardware and software to support the future missions are developed to reduce program risks and development costs and to obtain significant performance and reliability improvements through the effective use of new technologies.

BASIS OF FY 1977 ESTIMATES

In FY 1977 the Payload Integration and Mission Analysis efforts will focus on the Space Transportation System (STS) utilization planning, technical and cost tradeoffs for candidate operational concepts and plans related to the orderly transition to STS operations and phase-out of expendable launch vehicles. Payload operations and handling studies as well as the acquisition of payload description and design requirements will continue in FY 1977.

Advanced systems funding in FY 1977 will provide for the continuation of study efforts in the areas of a space station concept and assembly of large structures in space. Other efforts to be continued with FY 1977 funding include: the study of high performance upper stages for the STS; development engineering and testing of improved environmental support and protective equipment components; investigations of the use of new technologies for long life and readily maintainable subsystems for possible space station concept applications; investigations of support equipment and tools required for extended operations in space and studies of future space system concepts.

Payload Integration and Mission Analysis

1975	1976		Transition Quarter		1977
Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)			
5,000	6,000	6,000	1,800	1,800	5,000

OBJECTIVES AND STATUS:

The Payload Integration and Mission Analysis objectives are to assure hardware and operational compatibility between payloads and the Space Transportation System (STS) and to obtain the most effective use and economical operation of the STS. To achieve these objectives, activity focuses on three specific areas: (1) development of system requirements and the review of STS compliance with these requirements; (2) analysis of interfaces between the STS and its payloads and the definition of systems required to conform to these interfaces; and, (3) planning for payload operations and the operational interfaces between payloads and the STS.

In FY 1976 and the Transition Quarter, STS utilization planning activities are focusing on formalizing early Space Shuttle mission planning, improving the fidelity of STS utilization planning and refining the cost and economic analytical capability to support mission planning. Payload operations and handling studies are developing a greater understanding of payload ground and flight operations requirements and such hardware and software critical end items as STS payload integration simulators, payload specialist flight training facilities and operations, and payload/STS operations software interfaces. Payload analysis and requirements studies are being continued to refine payload descriptions and requirements, support analyses of the impact of STS changes on payload requirements, and provide data to better understand safety and contamination control requirements for payloads. Other activities include finalization of user pricing policy, STS user community development and advanced payload applications studies.

BASIS OF FY 1977 ESTIMATES:

In FY 1977, STS utilization planning will concentrate on updating the early Space Shuttle mission plan to include hardware inventories and logistics requirements, improving the responsiveness of cargo load planning, refining the cost estimating of Spacelab integration and formalizing transition planning methodology of conventional launch vehicles to the Space Shuttle. Payload operations and handling studies will be expanded to develop a greater understanding of payload ground and flight operations and associated critical hardware and software end items including Mission Control Center modification and software requirement studies. Payload analysis and requirement efforts will be continued in such activities as payload descriptions and requirements, payload operation centers' needs, STS change impact analysis, the support of the data bank, and safety and contamination control modeling studies. New user and applications tasks will be continued in the areas of STS user community development, advanced payload application studies, and support to implementing orbital servicing techniques.

Advanced Systems

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
11,000	12,000	12,000	3,500	3,500	13,000

OBJECTIVES AND STATUS:

The objective of Advanced Systems is to investigate concepts, technology, performance, cost and schedule data required for management to make decisions on future programs. It also provides for the technology support and advanced planning associated with the current expendable launch vehicle capability. Studies and laboratory investigations are performed on the definition and evaluation of advanced space systems; advanced concepts for space and ground operations needed for flight missions; the extension and new applications of existing systems; and integrated planning of future systems concepts. Investigations are conducted by small technical teams to detect and solve the problems of utilizing the latest technology in future space systems before committing its use in major future flight programs. This results in major cost avoidance by resolving problems associated with new technology use before reaching the critical schedule and high manpower phase of program development efforts and thereby increases the effective use of new technologies.

Significant progress was made during FY 1976 in Advanced Systems efforts. The early space station concept studies indicated that a small four to six man space station is feasible based upon utilizing Skylab, Shuttle and Spacelab technology and hardware with minimum modifications. The relatively new concept of utilizing a permanent space station as an operations base for erecting and maintaining space systems has resulted in parallel studies being initiated to determine alternative space station system configurations with the ability to evolve into an operational, multidisciplinary base and laboratory. An initial study of packaging, transportation, and erection of very large structures on-orbit such as would be required for a solar power station, was completed. Other advanced space operations including the development of concepts of space industrialization are being investigated. A new space modular computer and laser gyro measuring unit have been successfully tested in support of the space station concept and a long life radiator concept is being pursued. The engineering breadboard circuit verification has been completed for a solid state TV camera which would be required for on-orbit assembly and an engineering prototype for this camera, not much larger than a pack of cigarettes, is now being fabricated. Support of the above is a continuing effort to study future space transportation requirements with special effort on an orbital transfer vehicle. In addition, Shuttle booster concepts intended to reduce operating costs or improve performance are being investigated.

BASIS OF FY 1977 ESTIMATES:

The FY 1977 Advanced Systems funding will continue to support the expendable launch vehicle activities and space station concept studies initiated in FY 1976. This will lead to the selection of primary configuration concepts to be followed by their preliminary definitions, subsystem analyses and programmatic comparisons, such as power generation, thermal control, attitude and pointing control, communications and instrumentation data processing and contamination control techniques will be explored. Assembly of large structures in space will continue to be studied as well as investigations into future space operations, and support equipment and tools required for these operations. Study of high performance upper stages for the Space Transportation System in advanced lightweight structures, propellant management and propulsion subsystems will be continued in FY 1977. Conceptual studies of large space reflectors for earth illumination and nuclear waste disposal in space will also be initiated in FY 1977.

FY 1977 funding will also provide for development and testing of improved environmental support and protective equipment components to increase reliability and maintainability, decrease logistics resupply, systems weight and power requirements for future space missions. Subsystems integration testing and control methodology will be undertaken to provide more economical environmental support systems and improvements in comfort, mobility and cost of space suits. Emphasis will be placed on flight-quality instrument design and fabrication for identification and quantification of toxic gasses as well as development of environmental support components such as water reclamation and oxygen regeneration subsystems. Additionally, FY 1977 funding will provide for the continuation of study efforts to improve on-board contamination control, thermal control and communications subsystems to provide longer life, simpler, more reliable hardware at reduced costs.

Apollo Soyuz Test Project

Program Accomplishments:

The Apollo Soyuz mission resulted from a US/USSR agreement to develop compatible rendezvous and docking systems and to test them in orbit. This agreement was signed by President Nixon and Chairman Kosygin in Moscow in May 1972. When the Apollo spacecraft rendezvoused and docked with the Soyuz on July 17, 1975, a primary objective of the agreement - the feasibility of joint missions - was achieved. The flawless functioning of the compatible systems confirms that they will provide a basis for future manned space activity and a basis for space rescue.

During the two days following docking, the crews made four transfer operations between the two spacecraft and completed five scheduled joint scientific experiments. These included a Solar Eclipse Experiment and an Ultraviolet Absorption Experiment. The crews also provided television views of the interior of the two spacecraft and demonstrated various aspects of space operations. This mission marked the first time voice, television and telemetry were relayed between an orbital Apollo and the ground via the synchronous ATS-6 communications satellite. This new technique more than tripled the communications coverage otherwise available.

Altogether the scientific payload consisted of twenty-eight experiments which have already furnished valuable data. Experiments were conducted in the fields of earth resources, science, life sciences and space processing and manufacturing. While experimental data analysis is not yet complete, some significant results have already appeared.

In the Extreme Ultraviolet (EUV) experiment a strong source of radiation was detected which has been identified with a white dwarf star. This is the first successful investigation in the EUV wave length for sources outside our solar system. The discovery indicates that radiation previously thought to be undetectable because of absorption by interstellar hydrogen can, in fact, be detected. This is an important discovery because analysis of the source shows that observation in the EUV wave length range reveals new information about the structure of stars that emit this radiation.

The Ultraviolet Absorption experiment for the first time accurately measured the concentration of atomic oxygen and nitrogen in the upper atmosphere using evaluation of the degree of absorption of a light beam reflected from Soyuz. The experiment validated the technique which will be used for long term monitoring of the upper atmosphere in the Shuttle era.

The Marshall Space Flight Center electrophoresis experiment tested a static column method of electrophoretic separation of biological materials under zero gravity conditions. Problems encountered in two previous Apollo missions were resolved and the experiment was a success. An excellent pre-launch sterile technique was devised for handling the samples. Clear, sharp separation of cells was obtained in zero gravity operation and viable separated cells were returned to earth for analysis.

Of particular interest is the successful isolation of kidney cells that produce urokinase, an anti-clotting enzyme used in treatment of heart attacks and strokes. Urokinase is very difficult and expensive to produce on earth. The separated kidney cells have been cultured to grow additional quantities, and Abbot Laboratories believes the results are of major significance, with economic potential.

Data from the Earth Observation experiment is being analyzed for many applications. One interesting discovery in the field of desert geology is that similar dune shapes can be correlated to determine wind patterns and that relative age of deserts can be found by color differences. Together, this permits investigators to trace the direction and growth rates of deserts which will be very useful in studying drought areas such as in North Africa.

A summary science report on all the ASTP experiments will be published in March 1976. A final joint mission report has also been prepared. A Soviet delegation recently spent two weeks at the Johnson Space Center to collaborate with their NASA counterparts in this effort.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1977 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT

EXPENDABLE LAUNCH VEHICLES PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Scout	12,300	12,100	10,600	3,400	3,400	10,700
Centaur	75,400	113,800	110,100	26,400	24,400	90,700
Delta	51,800	36,600	41,800	10,300	9,300	43,800
Atlas-F	---	3,400	3,400	---	---	6,200
Total	139,500	165,900	165,900	40,100	37,100	151,400
Distribution of Program Amount by Installations:						
Kennedy Space Center	11,617	15,160	18,275	3,000	3,395	18,323
Goddard Space Flight Center	46,458	31,782	37,000	8,600	7,730	38,027
Wallops Flight Center	10	10	---	---	---	---
Langley Research Center	11,385	11,965	10,450	3,050	3,300	10,550
Lewis Research Center	68,075	102,168	95,450	24,700	22,200	77,100
Headquarters	1,955	4,815	4,725	750	475	7,400
Total	139,500	165,900	165,900	40,100	37,100	151,400

OFFICE OF SPACE FLIGHT

EXPENDABLE LAUNCH VEHICLES PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The expendable launch vehicles program provides for the centralized procurement of launch vehicle and launch support services for NASA's automated spacecraft missions. This includes the procurement of vehicle hardware, launch services, engineering and maintenance, and, as required, development of improved vehicle systems including the necessary ground support equipment. Launch vehicles currently being procured are: Scout, Atlas Centaur, Titan III Centaur, Delta, and Atlas-F.

The budget request for each launch vehicle includes two major categories: vehicle hardware and supporting activities. Funding related to vehicle hardware is identifiable with specific missions and includes such items as solid rocket motors, boosters, upper stages, shrouds, adapters, and mission peculiar hardware. The supporting activities category includes preparation of hardware for launch, guidance and control services, mission software, prelaunch and postlaunch engineering analysis, transportation, propellants, and range support.

The supporting activities effort differs from the vehicle hardware category in that resource requirements are directed to recurring costs which are level of effort in nature, rather than to the procurement of a specific number of end items of hardware produced.

BASIS OF FUND REQUIREMENTS:

Scout

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Hardware	4,100	3,000	1,600	500	900	2,400
Supporting activities	8,200	9,100	9,000	2,900	2,500	8,300
Total	12,300	12,100	10,600	3,400	3,400	10,700

OBJECTIVES AND STATUS:

The Scout launch vehicle was initiated by NASA in 1959 with the goal of economically launching a large variety of small scientific satellites, space probes, and reentry experiments. The first Scout launch occurred in July 1960. In the ensuing 15 years, there have been 93 launches. The vehicle has experienced a recent success record of 37 successful launches in a row until December 5, 1975, when it failed to place the Dual Air Density (DAD) mission into orbit. A failure review committee has been formed to investigate this failure.

The Scout vehicle is the smallest launch vehicle employed by NASA. It is a four-stage, all solid propellant launch vehicle. The vehicle is approximately 22.4 meters in length (73 feet) and the first stage booster has a diameter of 1.14 meters (3.75 feet). It is capable of placing a 180 kilogram (400 pound) payload in a 556 kilometer (300 nautical mile) orbit.

The Langley Research Center, located at Hampton, Virginia, has managed the Scout project since its inception. The prime contractor for the production, checkout, and launch of Scout is the Ling-Temco-Vought Aerospace Corporation, located in Dallas, Texas. Scout vehicles are launched from the Western Test Range, California; from Wallops Island, Virginia; and from the San Marco platform off the African coast near Kenya.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate

The reduction of $1.5 million in the FY 1976 estimate for the Scout project is due to a rephasing of hardware procurement. Funds were applied to the increased requirements in the Delta Launch Vehicle project.

Transition Quarter Estimate

The adjustment in the Transition Quarter, with no change in total, reflects a rephasing of procurement actions between hardware and support elements of the project.

BASIS FOR 1977 ESTIMATES:

Hardware - Funds will be utilized to continue hardware procurement to support the Heat Capacity Mapping Mission (HCMM) and the Stratospheric Aerosol and Gas Mission (SAGE).

Supporting Activities - Engineering and technical support, vehicle testing and checkout, launch operations, and maintenance of launch facilities and ground equipment will be funded to support vehicle checkout preceeding launch and the launch schedule. During FY 1977, checkout of the vehicle for the HCMM mission will be initiated, and activities will be continued to support future missions.

Centaur

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Hardware	23,900	60,200	56,600	10,600	11,200	42,400
Supporting activities	51,500	53,600	53,500	15,800	13,200	48,300
Total	75,400	113,800	110,100	26,400	24,400	90,700

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 being used with the Atlas booster for high energy missions, particularly planetary and synchronous orbits. The Atlas Centaur vehicle is 40 meters (131 feet) in length and has a diameter of 3.1 meters (10 feet).

The Centaur is also being used with the Titan booster to launch heavier spacecraft beyond the capability of the Atlas Centaur. In this configuration, the Titan Centaur has successfully launched the Helios-A and B missions and, during the past summer, the Viking-A and B missions. The Titan Centaur is 49 meters (160 feet) high and has a payload shroud diameter of 4.3 meters (14 feet).

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate

The reduction of $3.7 million in the FY 1976 estimate is a result of procurement rephasing and adjustments in the launch vehicle hardware estimates for the Mariner Jupiter/Saturn-A and B missions and the Helios-B mission. The $3.7 million made available by these adjustments has been applied to the Delta Launch Vehicle project.

Transition Quarter Estimate

The net decrease of $2.0 million in the Transition Quarter reflects adjustments resulting from the general Congressional reduction in NASA's R&D Budget Request for this three-month period.

BASIS OF FY 1977 ESTIMATES:

Hardware - Funds are required to continue incremental procurement of hardware to support Mariner Jupiter/Saturn-A and B, High Energy Astronomy Observatory (HEAO) A, B, and C, and Pioneer Venus-A and B.

Supporting Activities - Funding will be utilized for management and engineering support effort, launch support operations, field services and to maintain facilities and ground equipment. During FY 1977, three missions, for which funds are being requested, will be launched: HEAO-A and two Mariner Jupiter/Saturn missions.

Delta

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Hardware	19,500	12,300	7,200	1,000	2,600	12,800
Supporting activities	32,300	24,300	34,600	9,300	6,700	31,000
Total	51,800	36,600	41,800	10,300	9,300	43,800

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 118 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 three, six, or nine strap-on solid motors for thrust augmentation.

The second stage Delta, which provides a multiple restart capability, uses an inertial guidance system for guiding the first stage booster and the second stage Delta. The third stage utilizes the Thiokol TE-364 solid motor which is spin 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 pounds) into a 555 kilometer (300 nautical mile) orbit.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate

The net increase of $5.2 million in the FY 1976 estimate for this project reflects the increased support required to improve operating procedures and vehicle reliability, as recommended by the Failure Review Committee in 1974 when the Delta vehicle system was experiencing launch problems.

Transition Quarter Estimate

The net decrease of $1.0 million in the Transition Quarter reflects adjustments resulting from the general Congressional reduction in NASA's R&D Budget Request for this three-month period.

BASIS OF FY 1977 BUDGET ESTIMATES:

Hardware - Funds will be used to continue the launch vehicle hardware procurement contracts initiated in prior years, and to be initiated in FY 1977, in support of the Nimbus-G, International Sun-Earth Explorers A/B and C (ISEE), International Ultraviolet Explorer (IUE), and Landsat-C missions.

Supporting Activities - Necessary technical and engineering support to sustain vehicle test and check-out and launch operations, and to support maintenance of launch facilities and ground equipment, will be provided with FY 1977 funds being requested. Vehicles will be checked out and readied for launch in support of the IUE, Landsat-C, ISEE-A/B, ITOS-H, and GOES B and C missions.

Atlas-F

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Hardware	---	3,400	3,400	---	---	6,200

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 1977 BUDGET ESTIMATES:

FY 1977 funds will be used to complete efforts initiated in FY 1976 to refurbish and modify the Atlas-F launch vehicle in support of the launch of the Tiros-N meteorological satellite in 1978. In addition, funds are required to initiate work on an Atlas-F vehicle to support the SEASAT-A ocean dynamics satellite mission which is planned for launch in 1978.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1977 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE SCIENCE PROGRAMS

Programs	Budget Plan					
		1976		Transition Quarter		1977
	1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
	(Thousands of Dollars)					
Physics and astronomy.....	136,315	155,800	159,300	46,600	43,500	165,800
Lunar and planetary exploration.	261,200	255,100	254,100	72,100	67,700	191,100
Life sciences.....	19,800	20,800	20,800	5,950	5,200	22,125
Total.....	417,315	431,700	434,200	124,650	116,400	379,025

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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1977 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

PHYSICS AND ASTRONOMY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Large observatories	49,421	62,000	65,318	13,500	15,000	61,500
Spacelab science program	3,330	4,600	4,600	3,500	3,500	10,000
Orbiting explorers	33,945	33,000	29,682	11,000	7,400	33,000
Suborbital programs	24,834	24,800	24,800	7,500	7,500	26,000
Supporting activities	24,785	31,400	34,900	11,100	10,100	35,300
Total	136,315	155,800	159,300	46,600	43,500	165,800
Distribution of Program Amount by Installation:						
Johnson Space Center	947	1,000	1,237	200	300	2,458
Marshall Space Flight Center	50,029	71,400	73,967	20,550	19,037	46,250
Goddard Space Flight Center	55,940	53,038	54,122	17,075	13,954	74,843
Jet Propulsion Laboratory	628	700	958	400	170	1,700
Wallops Flight Center	2,404	2,800	3,675	800	926	3,900
Ames Research Center	7,126	7,400	7,145	1,950	1,293	6,500
Langley Research Center	1,358	862	697	925	281	1,340
Lewis Research Center	---	---	---	---	---	1,600
Headquarters	17,883	18,600	17,499	4,700	7,539	27,209
Total	136,315	155,800	159,300	46,600	43,500	165,800

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1977 ESTIMATES

OFFICE OF SPACE SCIENCE — PHYSICS AND ASTRONOMY PROGRAM

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Large Observatories:		
High Energy Astronomy Observatories	HEAO-A	1977
	-B	1978
	-C	1979
Solar Maximum Mission	SMM-A	1979
Spacelab	Spacelab-A	1980
	-B	1980
Explorers:		
Solar Terrestrial Explorers	International Sun-Earth Explorer-A/B	1977
	-C	1978
Astrophysics Explorers	International Ultraviolet Explorer	1977
Suborbital Programs:		
Sounding Rockets	About 65 launches per year	
Balloon Flights	About 40-50 launches per year	

OFFICE OF SPACE SCIENCE

PHYSICS AND ASTRONOMY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The major objective of the Physics and Astronomy program is to increase our knowledge and understanding of the 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 the advancement of scientific research, education, and technology. For example, major advances in special purpose microelectronics 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, begun in 1959, which have made a number of very basic discoveries, including the discovery of the Earth's radiation belts. Larger observatory missions undertaken to date include the Orbiting Solar Observatory (OSO) series and the Orbiting Astronomical Observatory (OAO) series; the highly successful OAO-3, launched in 1972, has completed three years of productive operations and is still obtaining significant data for analysis. 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 observer enhanced the capability of the largest observatory yet placed in orbit.

The year 1975 was a particularly active one, with five launches. The OSO-8, launched in June, 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 last of the Small Astronomy Satellite series, SAS-C, launched in June, is expanding on the discoveries of SAS-A(UHURU). Two Atmosphere Explorers, launched in October and November, are investigating the detailed processes which occur as a result of solar energy absorption in the lower regions of the Earth's atmosphere. A Dual Air Density (DAD) Explorer, designed to investigate the uppermost layers of the Earth's atmosphere, was launched in December, but did not achieve orbit due to malfunction in the launch vehicle. A study is underway to determine the possibility of a backup mission in 1976.

Work is continuing on the HEAO series which is 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. As a result of advanced technological development effort and mission planning, we are now proposing a Solar Maximum Mission (SMM) for launch in 1979, 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. Definition studies for a variety of payloads for the Shuttle are being supported. Development work will commence on several facility-type payloads which will lead to a large "laboratory in space" to conduct experiments utilizing the large weight-carrying capabilities of the Shuttle. A program of Upper Atmospheric Research has been developed, pulling together effort previously funded in other program areas as well as new initiatives. This program is designed to determine the normal composition of the upper atmosphere, with emphasis on understanding the effects of natural and man-caused events.

BASIS OF FUND REQUIREMENTS:

Large Observatories

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Orbiting solar observatories.....	4,305	2,600	3,600	500	900	1,000
Orbiting astronomical observatories	2,216	2,800	2,500	1,000	600	2,600
High energy astronomy observatories	42,900	56,600	59,218	12,000	13,500	36,600
Solar maximum mission.....	---	---	---	---	---	21,300
Total.....	49,421	62,000	65,318	13,500	15,000	61,500

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
(Expendable Launch Vehicles Program)						
Delta (OSO) and (SMM)	(2,000)	(---)	(---)	(---)	(---)	(---)
Atlas/Centaur (HEAO)	(2,200)	(19,500)	(19,500)	(5,100)	(2,500)	(15,200)
Orbiting Solar Observatories (OSO)						
OSO spacecraft	1,800	1,154	1,700	---	---	---
OSO experiments	2,505	1,446	1,900	500	900	1,000
Total	4,305	2,600	3,600	500	900	1,000

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 specific 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. 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-8 was launched in June 1975, near solar minimum. The last in the series, which began in 1962, it is continuing its study of energy transport in the Sun's lower atmosphere and corona. In addition, there are experiments on board which are measuring X-ray emissions from a variety of stellar and galatic sources and obtaining information about the Earth's atmosphere.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

The increase of $1.0 million is due to rephasing caused by a launch slip of OSO-8, as well as extensions of in-orbit operations through June 1977 and data analysis through June 1978. These extensions will allow us to capitalize on the continuing scientific returns of the operations.

Transition Quarter Estimate:

The increase of $400 thousand is also due to extensions of in-orbit operations and data analysis.

BASIS OF FY 1977 ESTIMATES:

Funding in FY 1977 will be used to support the scientific experiment teams necessary to operate the instruments and analyze the incoming data. Funding will also be used to support operation of the OSO-8 spacecraft in orbit. This includes staffing, by contractors, of the OSO Control Center at the Goddard Space Flight Center as well as supporting computer personnel required to adapt software used to provide commands to the observatory.

Orbiting Astronomical Observatories (OAO)

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
OAO orbital operations, data analysis	2,216	2,800	2,500	1,000	600	2,600

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), launched in 1972, is still operational, permitting observations of celestial objects and interstellar space in the spectral range from the X-ray through the ultraviolet and into the visible region.

OAO-3 carries the Princeton University 32-inch telescope system for investigating the interstellar medium at high resolution, and the University College London instrument for investigating celestial X-ray sources. FY 1976 and Transition Quarter funds support the operation of OAO-3, the analysis of data obtained by the Princeton experiment, and the Guest Investigator program.

CHANGES FROM BUDGET ESTIMATES:

The FY 1976 and Transition Quarter funding has been decreased by $300 thousand and $400 thousand, respectively, since several of the approved Guest Investigators are foreign scientists who are funded by their respective governments.

BASIS OF FY 1977 ESTIMATES:

FY 1977 funds will support OAO-3 in-orbit operations and provide for data processing and analysis of data obtained by the scientific experiments. These funds will also provide continuing support for the OAO Guest Investigator program.

High Energy Astronomy Observatories (HEAO)

	1975	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
			(Thousands of Dollars)			
HEAO spacecraft	23,497	34,009	34,509	7,000	7,500	18,800
HEAO experiments	19,403	22,591	24,709	5,000	6,000	17,800
Total	42,900	56,600	59,218	12,000	13,500	36,600

OBJECTIVES AND STATUS:

The basis scientific objective of the High Energy Astronomy Observatory (HEAO) program is to explore the previously inaccessible regions of celestial X-ray and gamma-ray sources and of cosmic-ray flux. This program has the potential to enhance substantially our understanding of newly discovered energy processes and of the creation of matter. It will also greatly improve our understanding of observed phenomena such as quasars, pulsars, novae, and supernovae.

Three HEAO's will be launched on Atlas-Centaur rockets from the Eastern Test Range. The first launch in 1977, HEAO-A, will be an X-ray survey. The second mission, HEAO-B, will carry a grazing incidence X-ray telescope and will make detailed studies of specific sources. The third mission, HEAO-C, will carry a combination of gamma-ray and cosmic-ray instruments; it will be capable of retrieval by the Shuttle for refurbishment and relaunch, and will be compatible with the Tracking and Data Relay Satellite System (TDRSS).

The FY 1976 and Transition Quarter funding supports the peak activity for HEAO. Critical design reviews for the spacecraft and the HEAO-B experiments will occur. The HEAO-A experiments and the spacecraft are currently being fabricated, with integration to begin in early spring of 1976. Verification of HEAO-A, as an observatory, will begin this year. The HEAO-B mirrors will be polished and the detectors built. The test and calibration facility at MSFC will be completed and testing of the mirrors will begin. The design effort on the HEAO-C flight instruments will continue. The Preliminary Design Review (PDR) for the HEAO-C instruments will also take place during this period. Mission operations efforts will include the preparation of the mission control center at GSFC as well as the preparation of required software.

CHANGES FROM BUDGET ESTIMATES:

The increase of $2.6 million in FY 1976 and $1.5 million in the Transition Quarter is the result of increases in the development costs of the HEAO-A experiments, which are scheduled to be completed in the spring of 1976, and greater than anticipated problems in the development of the HEAO-B X-ray telescope.

BASIS OF FY 1977 ESTIMATES:

FY 1977 funds will provide for the first launch of the program, HEAO-A. Activity leading to the launch will predominate, and will include complete verification of the observatory, delivery of the unit to KSC, checkout of the control center and the STDN network, and, finally, launch operations. Data analysis activity will also commence. The HEAO-B spacecraft and flight experiments will be completed and integration will begin. The Critical Design Review on the HEAO-C experiments will occur, and fabrication and checkout will be well advanced.

Solar Maximum Mission

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
SMM spacecraft	---	---	---	---	---	7,300
SMM experiments	---	---	---	---	---	14,000
Total	---	---	---	---	---	21,300

OBJECTIVES AND STATUS:

The major objective of the Solar Maximum mission (SMM) is to conduct detailed studies of the solar flare process and the associated solar active regions during the next period of peak solar activity occurring in 1978-1980. These investigations will be conducted over a broad spectral range, with high time, spectral, and spatial resolution, with the object of explaining the underlying physical mechanisms and complex energy transfer and high energy particle acceleration processes involved.

The accomplishment of these objectives will permit scientists to better understand the physical mechanisms involved in the pre-flare storage of energy, the flare "trigger" (i.e., the instantaneous release of the stored energy), the acceleration of particles to sub-relativistic and relativistic energies, the heating and cooling of the flare plasma, and the ejection of high energy particle streams into the corona and out into the solar wind. In addition, the interrelation of flare radiation and quiet and active sun emissions with the terrestrial environment (atmosphere, magnetosphere, and climate) will be studied by a variety of techniques. Solar constant and solar spectral irradiance monitors will be flown on the SMM; SMM flare particle observations will be compared with in-situ measurements of energetic particle streams, made near 1 AU by ISEE satellites; and the neutral atmospheric density and composition will be probed by means of ultraviolet and extreme ultraviolet atmospheric attenuation studies and airglow observations.

BASIS OF FY 1977 ESTIMATES:

During FY 1977, the hardware development phase will be initiated. This will include award of contracts for the design, fabrication, and testing of the scientific experiments, of the experiment module which supports the experiment complement, and of the service spacecraft subsystem modules.

Spacelab Science Program

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Spacelab science payload definition	3,330	3,500	3,500	900	900	4,000
Spacelab science payload development	---	1,100	1,100	2,600	2,600	6,000
Total	3,330	4,600	4,600	3,500	3,500	10,000

The Shuttle-launched Spacelab will offer unique opportunities to conduct space physics and astronomy research with instrumentation and operations similar to those used in ground-based observations. This program is building upon the experience and accomplishments of both previous and ongoing flight projects, including the very successful Skylab mission.

Spacelab Science Payload Definition

3,330	3,500	3,500	900	900	4,000

OBJECTIVES AND STATUS:

The objective of the Spacelab Science Definition studies is to identify experiments and facilities which can take advantage of the unique capabilities of the Shuttle/Spacelab system in the conduct of research in the fields of astronomy, high energy astrophysics, atmospheric physics, and space plasma physics. Science working groups have defined experiments which can be conducted in the new mode of operation made possible by the Shuttle, and definition studies of instruments, supporting systems, and operations procedures have begun.

In atmospheric and space plasma physics, a preliminary payload has been identified for study purposes, and Phase B definition studies are underway to define a facility called Atmospheres, Magnetospheres, and Plasmas-in-Space (AMPS) for multiple uses in space. Two contractors are conducting a detailed definition study to determine the optimum ground and flight operations procedures for such a space facility, the support requirements for the payloads, and the cost and schedule implications of the implementation phase.

In astronomy, the design and support requirements for a meter class, optical/ultra-violet telescope are ready for detailed definition studies. Similarly, studies to define the requirements for high energy astrophysics payloads and infrared telescopes are underway. In solar physics, definition studies have identified major scientific investigations to be conducted and the experiment development necessary to conduct them. From the astronomy and solar physics payload studies the most important requirement which has emerged is for a pointing system with sufficient accuracy and stability to conduct significant scientific investigations in the 1980's.

BASIS OF FY 1977 ESTIMATES:

FY 1977 funding for Spacelab Payload Definition will be used to finalize interface requirements for astronomy, high energy astrophysics, solar physics, and AMPS experiments. Definition of requirements for ground operations, test and checkout, and experiment integration for simulators and other facilities will be a major part of the FY 1977 effort. A more definitive analysis of schedules for development and flight of the various Spacelab payload instruments and facilities will be made.

Spacelab Science Payload Development

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
---	1,100	1,100	2,600	2,600	6,000

OBJECTIVES AND STATUS:

The Spacelab Science Payload Development Program will provide the capability for scientists to conduct spaceborne research experiments during the 1980-1990 time period in a wide variety of disciplines. The Spacelab program is intended to facilitate rapid turnaround of equipment and quick response to new concepts, ideas, and theories, and to rapidly address near-term problems. This program covers the design, development, and integration of scientific flight operation instruments and special support subsystems in the major disciplines of astronomy, high energy astrophysics, solar physics, and atmospheric sciences and space plasma physics.

An Announcement of Opportunity for the first mission will be released in February 1976 in order to solicit experiment proposals for this mission and make selections by the close of FY 1976. Agreements

between NASA and the European Space Agency (ESA) regarding ESA participation in the first mission have been concluded, with the specific instrument to be approved before the end of 1976.

The first Spacelab Payload is a joint effort with the European Space Agency. The scientific objectives for this flight have been jointly planned and agreed upon, and participation of scientists from ESA member nations on U.S. experiments, and vice versa, will be encouraged. This first flight has two major objectives:

Primary Objective - To verify the Spacelab system and subsystem performance capabilities, verify Spacelab/Orbiter and Spacelab/Experiment interface compatibility, and determine the Spacelab-induced research environments.

Secondary Objective - To obtain valuable scientific and applications data from a NASA/ESA multidisciplinary payload and to demonstrate to the user community the broad capability of Spacelab for such research.

The scientific objectives for this first payload have been formulated and approved by the Administrator of NASA and the Director of ESA. The key objectives are:

1. Investigate key natural cause and effects relationships in the near-Earth environment by performing experiments in the Earth's atmosphere;

2. Demonstrate the capability to investigate vapor, liquid and solid phase interactions under gravity-free conditions;

3. Conduct investigations on the effects of the space environment on body fluid redistribution, vestibular function; and growth, development, and organization of living systems such as man, animals, plants, cells and tissues.

The second Spacelab Payload is planned to emphasize astronomy, but will not preclude other disciplines. The second flight will also be a verification flight for Spacelab and will have the same primary objective as the first Spacelab flight, except that it will test different aspects of the Orbiter and Spacelab. An Announcement of Opportunity for the second mission will be released in the spring of 1976.

BASIS OF FY 1977 ESTIMATES:

The selection of scientific experiments for the first Spacelab mission will be made in the second quarter of 1976; selection for the second mission will be in the third quarter of 1976. The development of the experimental equipment and experiments for each of these missions will start early in FY 1977.

The overall project planning and conceptual mission design, begun in FY 1976, will continue for a third quarter 1980 launch of the first Spacelab mission. Similar activity, slightly delayed, will be required for the second Spacelab payload, scheduled for launch in the fourth quarter of 1980.

Orbiting Explorers

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Solar terrestrial explorers.....	19,071	22,547	22,060	6,600	5,393	13,408
Astrophysics explorers.....	14,874	10,453	7,622	4,400	2,007	19,592
Total.....	33,945	33,000	29,682	11,000	7,400	33,000
(Expendable Launch Vehicles Program)						
Delta.....	(6,200)	(5,800	(3,900)	(1,000)	(1,800)	(7,300)
Scout.....	(2,800)	(1,000)	(1,200)	(500)	(900)	(---)

The Explorer program is comprised of many individual projects and spacecraft. This program provides the principal means of conducting long-term investigations of the geophysical and near-Earth interplanetary environment and astronomical studies which do not require complex observatories. Included in the present program are missions to study atmospheric and magnetospheric physics; the radiation belts; the several magnetospheric boundaries; interplanetary pheonomena; and X-ray, gamma-ray, ultraviolet, and radio astronomy.

The design of Explorer spacecraft depends upon the nature of the particular missions involved. Generally, missions have been grouped into families which can be accommodated by a basic spacecraft design such as the Interplanetary Monitoring Platform (IMP), Atmosphere Explorer (AE), and Small Astronomy Satellite (SAS) series. Conceptual and systems studies to support projected missions are carried out on a continuing basis.

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.

Solar Terrestrial Explorers

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Atmosphere explorers (AE).....	8,305	5,500	5,704	1,200	1,250	2,700
International sun-earth explorers (ISEE).....	6,957	15,000	14,548	4,000	3,738	7,961
Other solar terrestrial explorers.....	3,809	2,047	1,808	1,400	405	2,747
Total.....	19,071	22,547	22,060	6,600	5,393	13,408

OBJECTIVES AND STATUS:

These Explorers provide the means for conducting studies of the Earth's near-space environment. The program requires a wide veriety 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 1975 was very successful and included the launch of the last two Atmosphere Explorer missions (AE-D and E) in October and November, respectively. The AE series consists of three missions, the first of which (AE-C) was launched in 1973. 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.

Work is also continuing on procurement of hardware and subsystems and fabrication of experiments for the International Sun-Earth Explorers (ISEE) missions, a cooperative program with the European Space Agency (ESA). A cooperative program with Italy for two additional San Marco missions is also being implemented, with launches scheduled for 1978/79. Conceptual and definition studies are also being pursued on a selected number of proposed missions submitted in response to Announcements of Opportunity issued in early FY 1975 and recommended by scientific review committees. The study pertaining to an Electrodynamic Explorer mission is now nearing completion.

CHANGES FROM BUDGET ESTIMATES:

The decrease of $487 thousand in FY 1976 reflects:

1. additional funding for a backscatter ultraviolet spectrometer (BUV) which was added to the AE-E spacecraft in order to measure the atmospheric distribution of ozone in the equatorial region;

2. a decrease in ISEE funding due to the rephasing of requirements, and;

3. a decrease in IMP funding due to rephasing of data analysis activity for the IMP H and J missions.

The decrease of $1.2 million in the estimates for the Transition Quarter reflects the deferral of definition studies and detailed design of some proposed missions as a result of the overall Congressional cut in NASA's R&D budget request for this period.

BASIS OF FY 1977 ESTIMATES:

Fiscal Year 1977 funds are required for in-orbit operations and analysis of data from the AE-D and E missions. In the ISEE project, funds will provide for completion of procurement of hardware and subsystems; fabrication of experiments for all ISEE missions; integration and start of flight acceptance tests for the ISEE-A and B missions scheduled for launch in 1977; and start of integration for the ISEE-C mission scheduled for launch in 1978. Funds are also required for final design and development activities on a number of high priority missions selected from new candidates; some Phase B definition studies; and continuation of acquisition, processing, reduction, and analysis of data from operational satellites.

Astrophysics Explorers

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Small astronomy satellites (SAS)...	4,350	1,638	1,250	500	506	1,056
International ultraviolet explorer (IUE).....	10,000	6,500	5,536	1,600	1,170	3,500
Infrared astronomy satellite (IRAS).....	---	---	---	---	---	6,000
Other astrophysics explorers.....	524	2,315	836	2,300	331	9,036
Total.....	14,874	10,453	7,622	4,400	2,007	19,592

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) with SAS-C, the last of the series, successfully launched in May 1975; the Radio Astronomy Explorers (RAE); the International Ultraviolet Explorer (IUE), which is an international cooperative effort with the United Kingdom (UK) and ESA; and cooperative astronomy missions with the UK (UK-5) and the Netherlands (ANS) which were successfully launched in 1974.

The Astrophysics Explorers permit the study of various regions of the electromagnetic spectrum. 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 the UK and ESA will provide, respectively, the imaging system and the solar panels for a NASA spacecraft. This equipment, plus a planned ESA ground station, represents a European commitment of more than $18 million to the IUE project.

As in the case of Solar Terrestrial Explorers, a number of proposed experiments have been identified as candidate payloads for inclusion in conceptual studies of several proposed Explorers. Conceptual and definition studies will be pursued on the Infrared Astronomy Satellite, an explorer to monitor transient X-ray sources and gamma-ray bursts, and an explorer to carry a X-UV and soft X-ray telescope. These studies are being undertaken in response to Announcements of Opportunity issued in early FY 1975 and recommended by scientific review committees.

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CHANGES FROM BUDGET ESTIMATES:

The reductions of $2.8 million in FY 1976 and $2.4 million in the Transition Quarter reflect:

1. decreased funding for SAS due to rephasing of support for SAS-C data analysis;

2. decreased funding for IUE resulting from a 7-month slip in the program due to development problems in the UK camera system, and;

3. the decision not to proceed at this time with the detailed design and hardware phase of the Gamma-Ray Explorer.

The decrease in the estimates for the Transition Quarter also reflect adjustments resulting from the general Congressional reduction in NASA's R&D budget request for this three-month period.

BASIS OF FY 1977 ESTIMATES:

Fiscal Year 1977 funds are required for final integration, test and launch of IUE; final design and development activities on a number of high priority missions selected from new candidates with major emphasis on the Infrared Astronomy Satellite; some Phase B definition studies; in-orbit operations and analysis of data from the SAS-C mission; and continuation of acquisition, processing, reduction, and analysis of data from other missions previously launched.

Suborbital Programs

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Sounding rockets	19,976	20,000	20,000	6,200	6,200	20,700
Airborne research	3,858	3,800	3,800	1,000	1,000	3,800
Balloon program	1,000	1,000	1,000	300	300	1,500
Total	24,834	24,800	24,800	7,500	7,500	26,000
(Expendable Launch Vehicles Program)						
Scout	(1,300)	(---)	(400)	(---)	(---)	(---)

Sounding Rockets

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
19,976	20,000	20,000	6,200	6,200	20,700

OBJECTIVES AND STATUS:

The sounding rocket program provides a low cost and versatile tool for scientific research in the sub-orbital space environment. This program provides broad-based support of all of the scientific disciplines, including the study of cosmic dust and interplanetary matter, magnetospheric 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 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.

During 1975, approximately 30 sounding rocket launches with coordinated balloons and aircraft observations were successfully conducted at a launch site in Peru near the geomagnetic equator. These equatorial stratospheric and ionospheric observations were also correlated with the Backscatter radar on the AE-C satellite.

In the magnetospheric physics area, continued emphasis is being placed on lower ionospheric measurements (low altitude measurements which can only be done with sounding rockets) and vertical scans correlated with AE satellite measurements.

The solar physics sounding rocket program will continue to form an important part of the research in this area of physics and astronomy activity. After the intensive effort related to ATM calibration and collaborative investigations, the emphasis has now shifted to similar activities in support of the OSO-8 mission. In addition, new instrumentation for studies of both quiet and active solar features is being developed and tested.

In the astronomy area, continuing emphasis is being placed on measurement of stars and extended sources in both the UV and X-ray regions. Many observations are following up on the earlier measurements made with 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. Of special interest are the preparations for a series of sounding rocket flights (approximately eight) to make X-ray and UV observations in the southern skies from the launch site at Woomera, Australia. Scientifically interesting objects in our galaxy and in certain nearby galaxies cannot be viewed from the Northern Hemisphere and must, therefore, be observed from the Southern Hemisphere.

The Gravity Probe-A project, which was initiated in FY 1972 to confirm with improved accuracy the gravitational redshift (relativistic frequency shift) predicted by Einstein's Theory of Relativity, is now undergoing environmental tests, and during 1976, the flight will be performed and data analysis initiated.

BASIS OF FY 1977 ESTIMATES:

During FY 1977, there will be a continuation of most of the activities described above, with emphasis on the coordination of rocket launches and on correlation with satellite observations. Data analysis for the Gravity Probe-A mission will be completed and final reports prepared.

Airborne Research

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
3,858	3,800	3,800	1,000	1,000	3,800

OBJECTIVES AND STATUS:

Research with instrumented jet aircraft has been an integral part of the overall NASA program in Astrophysics since 1965. The aircraft platform provides a large payload capacity and facilities for extending observations over any region of the earth. It also may be transported readily to high operational altitudes, near 15 km (50,000 feet) in order to provide a cloud-free site for geophysics experiments and astronomical observations. The possibility of conducting experiments at this cloud-free altitude has been essential in opening to astronomy the infrared region of the electromagnetic spectrum from 10,000 Angstroms to 1 millimeter. The airborne platform has the further advantage of enabling scientists to participate directly in the space experiment.

The 91-cm IR telescope on the C-141A aircraft began operational flights in 1974 and is now in active operation. The 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).

Initial results from the use of the Airborne Observatory include the discovery of water vapor on Jupiter and the discovery of the "Egg Nebula", which is believed to be a solar system in the process of formation.

Infrared astronomers have actively participated in the Airborne Research Program for over four years, utilizing a 30-cm telescope carried on a Lear Jet. This Lear Jet Program involves, at present, about eight groups.

The FY 1976 Airborne Research Program funds are being used to support more than a dozen scientific groups using the C-141A. This includes a recent expedition to Hawaii involving four groups making far IR observations of the center of our galaxy. The Lear Jet astronomical program continues to support infrared astronomy objectives.

BASIS OF FY 1977 ESTIMATES:

The FY 1977 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 research program will be continued.

Balloon Program

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
1,000	1,000	1,000	300	300	1,500

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 least expensive to fly these experiments on balloons. The feasibility of ballooning as a cost effective tool for conducting research has been established by important scientific discoveries including the IR measurement of objects not detected by any other means, a far infrared celestial survey along the galactic plane, and detailed mapping of complex cold gas regions where stars are in the process of formation. The funding for this program is utilized for balloons, helium, launch services, tracking and recovery, while funding for the experiments is provided from Supporting Research and Technology (SRT). Approximately one million dollars has been expended annually for this program; this level of funding, in the past, has supported about 60 balloon flights a year, but the number has decreased significantly as a result of the effects of inflation and the higher costs of balloons, which are a petroleum-based product.

BASIS OF FY 1977 ESTIMATES:

The 1977 funding is required to support an increase in the number of scientific balloon flights as well as to provide "superpressure" balloons to meet the higher altitude and longer duration requirements of the science investigators. These funds will also provide for balloon flights in support of the FY 1977 upper atmospheric research program.

BASIS OF FUND REQUIREMENTS:

Supporting Activities

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Supporting research and technology (SR&T)	13,870	14,400	14,400	4,000	3,600	14,700
Data analysis	5,000	5,000	5,000	1,300	1,300	5,000
Skylab data analysis	1,400	6,000	6,000	1,500	1,500	4,000
Space telescope (ST) - advanced technological development	3,000	5,000	5,000	3,000	2,000	---
Solor maximum mission (SMM) - advanced technological development	1,515	1,000	1,000	1,300	700	---
Upper atmospheric research	---	---	3,500	---	1,000	11,600
Total	24,785	31,400	34,900	11,100	10,100	35,300

Supporting Research and Technology (SR&T)

	13,870	14,400	14,400	4,000	3,600	14,700

OBJECTIVES AND STATUS:

The SRT efforts enhance the overall scientific and technological return from NASA flight projects, and help 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 and laboratory experiments;

2. Development of theories to explain observed pehnomena 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 the physics of the Earth's environment. It includes study of the Sun-Earth environmental factors. Research supported in the field of solar physics involves the study of the sun and includes studies of the solar atmosphere and the influence of the sun on interplanetary and planetary environments, work on instrument development, and laboratory and theoretical studies of basic physical processes peculiar to the sun. Research supported in the field of astronomy involves objects outside the solar system and cosmic rays, and includes observations by ground-based and balloon-borne telescopes. Theoretical studies of stars, galaxies, and interstellar and intergalactic matter, and advanced development work on experimental tests of the validity of Einstein's Theory of General Relativity are also supported in this area.

During FY 1976 and the Transition Quarter, about 225 tasks are being supported at universities, non-profit and industrial research institutions, NASA Centers, and other Government agencies in 26 states and the District of Columbia. These include continuing studies of advanced missions, Advanced Technological Development (ATD) of solid state detector devices and improved photometers, and superfluid helium research.

CHANGES FROM BUDGET ESTIMATES:

SRT funding in the Transition Quarter has been reduced by $400 thousand as a result of adjustments resulting from the general Congressional reduction in NASA's R&D budget request for this three-month period. This will necessitate the postponement of certain tasks and mission planning activity.

BASIS OF FY 1977 ESTIMATES:

During FY 1977 continued support will be given to those tasks which are critical to maintaining a firm base for a viable Physics and Astronomy program. Superfluid helium research will be continued for cryogenic systems with future applications in relativity, cosmic ray, and infrared astronomy. Theoretical and experimental studies will be undertaken to investigate the unique properties of superfluid helium and its reaction to long-term operation in the space environment. Special emphasis will be placed on studies for advanced instrumentation involving image tubes and solid state devices which will increase both the sensitivity and resolution of detectors. These instruments will be required to detect and display astronomical data with extreme fidelity. Other technological problems concerning on-board data processing and storage, on-board data compression, pointing and stabilization, and detector background radiation will be studied. Basic studies will be continued to define future scientific objectives in astronomy and physics that will utilize the capabilities of the Shuttle.

Data Analysis

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
5,000	5,000	5,000	1,300	1,3( )	5,000

OBJECTIVES AND STATUS:

The purpose of this effort is to obtain the maximum return on the investment represented b the data gathered in the Space Science program, including that from a number of spacecraft which are rating well beyond their planned lifetimes.

Limited operation of spacecraft, beyond the times originally planned, has made additional d. available for specific investigations, with preference being given to correlative operations designed tc luminate physical problems, and to the exploitation of unusual opportunities such as unexpected encount 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 (NSSDC).

The operation of the NSSDC is also supported under this project. The NSSDC, located at the GSFC, was established to serve as a central repository and clearinghouse for scientific data resulting from space investigations.

BASIS OF FY 1977 ESTIMATES:

Fiscal year 1977 funds will provide support for the operation of the NSSDC, and for the data analysis activities of about 95 principal investigators at approximately 45 institutions including NASA field centers.

Skylab Data Analysis

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
1,400	6,000	6,000	1,500	1,500	4,000

OBJECTIVES AND STATUS:

The Skylab Data Analysis project supports the analysis and synthesis of data gathered by the ATM and Skylab experiments in Physics and Astronomy, and the ATM Guest Investigator and Coordinated Observing Programs. A series of workshops and symposia on ATM results are also supported.

The data acquired by the six major ATM instruments, together with that obtained by the world-wide program of complementary ground-based and rocket-borne observations, is unique in that it represents the first successful attempt at simultaneously studying the structure of the outer solar atmosphere at all heights from the photosphere to the outer corona. The analyses conducted so far have resulted in advances in a wide variety of areas of solar research. The heating of the outer solar atmosphere has been studied by determining the height structure of the chromospheric network and by investigating the various forms of oscillations present. The structure and evolution of sunspots, bright points, active regions and prominences have been studied and significant advances made in man's knowledge of the temperature and density structure of these features. A wide variety of transient events have been analyzed and a better understanding has been gained regarding the physics of the hot flare plasma, the possible forms of flare precursors, and the causes and characteristics of coronal transient events. The physical characteristics of coronal holes were also studied and their relationship with high velocity solar wind streams was verified. The discovery of the rigid rotation characteristics of these features by ATM scientists may shed some light on solar convection and circulation theory.

In addition to the topics discussed above, the Skylab FY 1976 activities have concentrated predominantly on the completion of the atlas production and the cataloging and preparation of data for the National Space Science Data Center (NSSDC). During the year, collaborative efforts have been extended, both among the ATM groups, and between these groups and their Guest Investigators. The first Skylab Workshop Series, which is on the subject of coronal holes, commenced in October 1975 and has successfully encouraged a number of additional scientists from related theoretical and experimental fields to work with the ATM group. Two further meetings in this series will take place during the spring and summer of 1976. A second workshop series, on a new topic, will commence at the beginning of the Transition Quarter.

BASIS OF FY 1977 ESTIMATES:

In FY 1977 the emphasis will continue to shift from data reduction, cataloging and atlas preparation to the intensive data analysis activities. The size of the supporting staff required by the ATM teams will thus be reduced. A basic core of these support personnel will, however, be required both to support the ATM scientists and to satisfy the increasing requirements of the Guest Investigators and the Skylab Workshop participants.

The increasing number of collaborations are beginning to capitalize more fully on the complementary aspects of the ATM mission and it is anticipated that it is in these areas of data synthesis that the most exciting advances may be made in the coming year.

Space Telescope (ST) - Advanced Technological Development (ATD)

1975	1976		Transition Quarter		1977
Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)			
3,000	5,000	5,000	3,000	2,000	---

OBJECTIVES AND STATUS:

The Space Telescope is under study as a possible future mission to orbit a high resolution telescope system in space for use by the astronomical community, and to take advantage of the Space Shuttle for launch, on-orbit servicing, and return to Earth for refurbishment.

FY 1976 and Transition Quarter funding supports the completion of the three Support System Module contracts and the two Optical Telescope Assembly contracts. The final study reports are planned for completion in early Calendar Year 1977. Contractor outputs will be considered in the preparation of statements of work and specifications for Request for Proposals for the Phase C/D design and development contracts. Negotiations with the European Space Agency regarding its interest in providing a Faint Object Camera and the solar array, and developing a photon counting image detector are continuing. ATD work is continuing, with the major part of the effort devoted to the SEC Orthicon detector. Perkin-Elmer is continuing with work on mirror coatings and ultraviolet scattering. Other ATD contracts include the stray light analytical program, model testing, and pointing control system studies. Technology proposals associated with the scientific instruments will be funded. Studies of the effects of radiation on instruments and detectors, will also be conducted.

In response to the desires of Congress for lower cost options, NASA examined telescopes which ranged in size from 1.8 to 3 meters, and determined that the 2.4 meter telescope would be cost effective and still meet the scientific requirements as specified by the astronomers and scientists.

The definition studies underway have served to develop an experienced and knowledgeable team and have provided the engineering and cost information required for the hardware phase.

CHANGES FROM BUDGET ESTIMATES:

Funding in the Transition Quarter has been reduced by $1.0 million in accordance with Congressional direction.

Solar Maximum Mission (SMM)
Advanced Technological Development (ATD)

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
1,515	1,000	1,000	1,300	700	---

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 objective of SMM is 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 the conceptual design studies of the supporting spacecraft systems and associated ground operations facilities were completed. The design concept provides for a spacecraft which capitalizes on common components and standardized subsystem 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.

In 1975, a preliminary science payload was selected. Thirteen individual experiments were studied to further define their technical and resource requirements. A technical and scientific review of each candidate experiment was conducted in late 1975. A final scientific payload of approximately seven experiments is expected to be selected in early 1976.

During FY 1976 and the Transition Quarter, project definition studies will be performed on the spacecraft and on the complement of experiments selected for flight in order to define, in detail, the interfaces of the complete SMM system. This effort will permit detailed design and development to proceed with fixed requirements in subsequent years.

CHANGES FROM BUDGET ESTIMATES:

The Transition Quarter budget estimate has been reduced by $0.6 million in the process of meeting the adjusted Congressional funding levels. This reduction results in the deferral of structural/thermal model studies related to experiment accommodations on the spacecraft.

BASIS OF FY 1977 ESTIMATES

The initiation of development activity for the Solar Maximum Mission in FY 1977 is described under the Large Observatories category of the Physics and Astronomy program.

Upper Atmospheric Research

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
---	---	3,500	---	1,000	11,600

OBJECTIVES AND STATUS:

A coordinated program of Upper Atmospheric Research was started in the Office of Space Science in 1975 in response to direction given in the FY 1976 NASA Authorization Act. It was formulated from work in other NASA offices and from new work started during FY 1976.

The NASA goal in Upper Atmospheric Research is to determine the normal composition of the atmosphere, with emphasis on the stratosphere. The long term objective of the program is the development of a better understanding of the physical and chemical processes occurring in the upper atmosphere. For the short term, program resources are being applied to assessments of the effect on ozone levels in the stratosphere from chlorofluoromethanes, Shuttle effluents, aircraft effluents, and other chemicals.

Since program inception, the assessment of ozone reduction by the Space Shuttle has been lowered based on data obtained related to Shuttle exhause products. A full report concerning the impact of Space Shuttle operations will be issued in May, 1976. Vertical profiles of hydrogen chloride, believed to be a sink for chlorine atoms, were obtained from balloon and U-2 aircraft platforms. A measurement of the stratospheric hydroxyl radical was made for the first time. Measurement systems have been expanded with the completion of the third Global Air Sampling Program (GASP) package on a Qantus 747 and with the addition of a fluorocarbon measuring capability on the U-2. Measurement of some chlorine and chlorine oxide reaction rates at stratospheric temperatures are being found to be lower than previously held values. A preliminary assessment of the impact of chlorofluoromethanes on ozone levels will be completed in August, 1976.

CHANGES FROM BUDGET ESTIMATES:

The Upper Atmospheric Research program was initiated in response to Congressional direction, as reflected in the NASA Authorization Act, 1976 (89 Stat. 218).

BASIS OF FY 1977 ESTIMATES:

In FY 1977, Upper Atmospheric Research funds will be used to support work in the following areas:

Field Measurements - Measurements will be made to obtain data on chlorine and related compounds to assess the impact of chlorofluoromethane releases on the stratospheric ozone levels. A final assessment report will be issued in September 1977. Measurements will also be made to obtain data on tropospheric and stratospheric trace constituents to assess the interactions of aircraft exhaust emissions with the natural atmosphere. Data will be obtained from the following measurement platforms - aircraft, balloons, sounding rockets, and satellites.

Laboratory Measurements - Measurements will be made on the rates of chemical reactions thought to be occurring in the upper atmosphere. Investigations will be conducted for sensor development and the refinement of measurement techniques. Considerable effort will be placed on the determination of spectroscopic properties of trace constituents.

Theoretical Studies - Efforts to develop and refine mathematical models of the upper atmosphere will be continued. Sophisticated models using results from the lab and field measurements activities will be used to provide assessments of the effects of chlorofluoromethane and aircraft emissions on the atmospheric ozone layer.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1977 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

LUNAR AND PLANETARY EXPLORATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Viking	89,016	39,500	39,500	14,000	11,600	24,200
Outer Planets Missions	69,761	82,400	82,400	22,600	22,100	50,300
Pioneer/Helios	33,642	62,600	61,700	16,300	16,400	47,400
Mariner Venus Mercury	5,324	---	---	---	---	---
Supporting Research and Technology/Advanced Studies	11,000	11,000	11,000	2,800	2,500	11,600
Planetary Data Analysis	1,628	1,400	1,400	400	400	2,500
Planetary Astronomy	4,200	4,200	4,200	1,100	900	4,800
Planetary Flight Support	24,725	29,300	29,200	8,800	8,700	27,900
Lunar Research Program	21,904	24,700	24,700	6,100	5,100	22,400
Total	261,200	255,100	254,100	72,100	67,700	191,100

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Distribution of Program Amount by Installation:

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Johnson Space Center	12,100	10,884	10,815	2,839	2,250	11,925
Marshall Space Flight Center	60	---	---	---	---	---
Goddard Space Flight Center	8,387	7,553	8,167	1,640	1,127	8,625
Jet Propulsion Laboratory	89,636	98,197	98,226	28,303	25,735	70,150
Wallops Flight Center	55	55	55	25	15	50
Ames Research Center	36,971	63,975	62,203	16,857	16,950	48,220
Langley Research Center	93,784	48,914	48,976	16,151	15,765	27,008
Headquarters	20,207	25,522	25,658	6,285	5,858	25,122
Total	261,200	255,100	254,100	72,100	67,700	191,100

OFFICE OF SPACE SCIENCE

LUNAR AND PLANETARY EXPLORATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The Lunar and Planetary Exploration Program includes scientific investigations of the Moon, the planets and their satellites, asteroids, comets, and the particles and fields of interplanetary space. The major objectives of these investigations are to understand the origin and evolution of the solar system and to apply the results of the investigations toward a better understanding of our planet Earth. The program has been highly successful to date and has provided extensive information on the Moon and on the planets Mercury, Venus, Mars, and Jupiter. Already, important new insights into the dynamic behavior of Earth are being derived from the integrated analysis of the total lunar and planetary data base.

Ground-based supporting programs continue planning, research, design definition, technology and instrument development, and data analysis and synthesis tasks. Earth-based remote observations permit important data gathering via optical, radio, and airborne instruments, which complement and supplement spacecraft measurements taken in space to achieve the best overall result. An important augmentation of these Earth-based capabilities will be the Infrared Telescope currently being designed for installation on Mauna Kea peak in Hawaii.

The currently approved Mars exploration program continues and expands on the investigations begun with Mariners 4, 6, 7, and 9. In 1971 and 1972 Mariner 9 carried out its extensive mapping of the Martian surface and gave the world the first detailed maps of Mars. In 1975 NASA embarked on a continuation of the Mars program by launching two Viking missions on August 20, 1975, and September 9, 1975. These missions include two orbiters and two landers and will give us our first in situ measurements on the surface of another planet. The landers are the most sophisticated automated vehicles ever built and will place on the surface several scientific "laboratories", including life detection instruments which will search for living organisms on Mars.

In 1974, Mariner 10 gave us our first closeup view of Mercury and Venus. In 1978, two Pioneer missions will be launched to further investigate Venus. One of these missions will provide an overview of Venus from orbit while the second, a multi-probe mission, will give us our first detailed in situ measurements of the Venusian atmosphere.

Helios A, which was designed to investigate the Sun from closer range than ever before, was launched on December 10, 1974, and has been a highly successful mission. Helios B was successfully launched on January 15, 1976. The Helios missions are cooperative missions between the United States and West Germany.

Pioneer 10 is now escaping the solar system and Pioneer 11 is on its way to encounter Saturn in September 1979. In 1977, two Mariner Jupiter/Saturn missions will be launched to expand our knowledge of these two planets. These spacecraft will also make first-ever scientific measurements of several of the planet-like satellites of the two giant planets.

In the Lunar Program a concentrated scientific effort is underway to analyze and interpret the large and still growing body of data acquired from lunar flight programs, ground-based observations of the Moon, and laboratory investigations. The analytical work that has been carried out to date has revolutionized previous theories of the formation, history, and structure of the Moon, and promises to make vital contributions to our understanding of planetary bodies in general. Nearly 100 Principal Investigators and several hundred Co-Investigators are now participating in a Lunar Data Analysis and Synthesis program designed to combine and cross-correlate all available data on the Moon. This effort is already having an impact in other areas of lunar and planetary research where experimental and theoretical studies are being conducted to answer specific questions raised by these investigators. While much of the information on which this effort is based has come from the analysis of lunar samples, only a small fraction of the collection has been analyzed to date. The main portion of the sample collection is being preserved in order to promote an orderly program and to permit future analyses with advanced techniques.

New data on the physical characteristics of the Moon over extended time periods is still being gathered by the Apollo Lunar Surface Experiments Packages (ALSEPs). In addition, other work, such as laser ranging, is being carried out to develop a more accurate ephemeris of the Moon and a more precise libration model, and to contribute to the study of tectonic plate movement of the Earth and irregularities in the Earth's whole body movement. Studies are underway to determine the scientific merit and feasibility of a small polar orbiter which would extend current measurements over the entire Moon and generalize our knowledge of that body.

BASIS OF FUND REQUIREMENTS:

Viking

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Orbiter spacecraft and science....	28,300	---	---	---	---	---
Lander spacecraft and science.....	53,916	---	---	---	---	---
Orbiter operations.....	---	11,300	13,000	8,200	6,200	1,800
Lander operations.....	---	22,300	22,500	2,300	3,100	1,200
Project management.....	6,800	5,900	4,000	3,500	2,300	900
Extended mission operations.....	---	---	---	---	---	20,300
Total.....	89,016	39,500	39,500	14,000	11,600	24,200
Titan/Centaur (Expendable Launch Vehicle Program).....	(6,200)	(300)	(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. Emphasis will be placed on obtaining biological, chemical, and environmental data relevant to the existence of life on the planet.

The Viking spacecraft were launched successfully on trajectories to Mars on August 20 and September 9, 1975 by Titan/Centaur launch vehicles. Each spacecraft consists of an Orbiter and a Lander. When the spacecraft arrive at Mars in the summer of 1976, each spacecraft will be placed in a 24-hour orbit around the planet. After the Orbiter instruments have carefully surveyed the intended landing sites, each Lander will be separated from its Orbiter and descend to the surface, conducting atmospheric investigations during the descent. Following its soft landing, the Lander will take panoramic color pictures and biological, geochemical, seismological, meteorological, and other scientific investigations will be conducted. The two Landers will conduct these experiments on the surface at two widely-spaced landing sites for a period of about 60 days each during the primary mission. The two Orbiters will view the

surface with high resolution cameras, obtain data on dynamic planetary processes, and act as communication relay stations for both Orbiter and Lander scientific data. An extended Mission, at a reduced level of effort, is planned for the period after November 1976 to observe seasonal and long-term variations in the environment.

During FY 1976, funds are being used to support operation of the two spacecraft during their interplanetary cruises; continuation of software development, training, and preparations necessary for planetary operations; and planetary operations beginning in June 1976 when the first spacecraft reaches Mars. Transition Quarter funding will support the high activity period during July, August, and September 1976, when the Lander from Viking 1 touches down on the planet, the Viking 2 spacecraft arrives at Mars, and the Lander from Viking 2 also lands. Analysis of the scientific data will begin during this period.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 changes between project element estimates reflect the solution of problems encountered during final pre-launch test checkout period. The Transition Quarter reduction of $2.4 million reflects a portion of the Congressional reduction made to agency funding for that time period. This will result in delays in second-order data processing during the planetary phase of mission operations.

BASIS OF FY 1977 ESTIMATES:

At the beginning of FY 1977, the landed portion of the basic Viking mission will be about 2/3 completed. Viking 1 Lander will have completed its primary experiments and will be monitoring the Martian environment; however, the Viking 1 Orbiter will still be engaged in planet-wide surveys. Viking 2 Lander will still have about 40 days of landed experiments to complete in the primary mission. Viking 2 Orbiter will be acting as a radio relay station as well as making global observations. This will be a period of high activity because of the multiplicity of the return data streams and of the spacecraft to monitor and command. Engineering and scientific data will be analyzed as rapidly as possible so that spacecraft operations can be adapted to any unusual happenings or discoveries. A total of about 700 persons will be involved the the flight team activities.

The primary mission will end about mid-November 1976 at superior conjunction when the Sun is between Earth and Mars. The 80 scientists participating in the flight operations will have from this time to the end of March 1977 to complete their preliminary scientific reports.

The Viking Extended Mission will begin in December 1976, and continue through most of the remainder of FY 1977. The four spacecraft at Mars will be operated by a reduced flight team to accomplish science

investigations which could not be performed during the primary mission. It may be desirable to perform another biology analysis with a long-term incubation period. Atmospheric composition and meteorological measurements will continue to be made to understand the Martian seasonal changes. Instruments on the Orbiters will concentrate on global variable features such as dust storms, polar caps, and cloud formations.

If warranted by the condition of the spacecraft and the continuing value of the science results, it is planned to continue the Viking Extended Mission through an entire Martian year, to about August 1978.

Outer Planets Missions
(Mariner Jupiter/Saturn 1977)

	1975	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
			(Thousands of Dollars)			
Project management & mission design	3,517	4,200	4,140	1,600	1,440	2,000
Spacecraft development	51,019	58,800	55,470	14,800	14,960	27,900
Science	14,165	15,200	17,730	3,300	3,900	12,800
Mission operations	1,060	4,200	5,060	2,900	1,800	7,600
Total	69,761	82,400	82,400	22,600	22,100	50,300
Titan/Centaur (Expendable Launch Vehicle Program)	(7,200)	(33,600)	(28,900)	(4,500)	(5,000)	(11,100)

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 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 1980/81. 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 Mariner-class spacecraft, with its greater amount of 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 770 kg (1,700 lbs.), will use the Energy Research and Development Administration's Multi-Hundred-Watt Radioisotope Thermoelectric Generators for power, and will carry approximately 100 kg (220 lbs.) of instruments. The spacecraft has been designed to use applicable Viking Orbiter subsystem designs and available residual Viking Orbiter hardware. The launch vehicle will be the Titan IIIE/Centaur D-IT, and the spacecraft includes a propulsion module to provide the final required increment of injection velocity.

In FY 1976 and the Transition Quarter, Mariner Jupiter/Saturn 1977 (MJS77) activities consist of completion of subsystem and science instrument development and critical design reviews, fabrication of flight hardware, selection of flight trajectories and a major portion of the implementation of the mission operations design. Structural and temperature control model spacecraft will be assembled and tested to verify the configuration design. Hardware for the proof test model (PTM) spacecraft will be delivered at the end of the fiscal year leading to PTM assembly during the Transition Quarter. Detailed planning of science observation sequences will continue through this period to aid in final flight trajectory selection and detailed mission operations planning.

CHANGES FROM BUDGET ESTIMATES:

Changes within the elements of this project in FY 1976 and the Transition Quarter, with a net reduction of $500 thousand in the Transition Quarter, were due largely to the modification of designs and implementation of plans to accomplish the radiation hardening of the spacecraft required to withstand the Jupiter environment. Changes were also brought about by minor development problems and schedule changes in some of the spacecraft subsystems and science instruments.

BASIS OF FY 1977 ESTIMATES:

FY 1977 funding requirements will provide for:

Project Management and Mission Design - Activities will consist of the continuation of detailed navigation and maneuver design, precision ephemeris development, final selection of the flight trajectories, and planning of launch and early mission activities.

Spacecraft Development - During the first quarter, system level testing of the proof test model spacecraft including type approval vibration and thermal vacuum testing will be completed. In addition, the flight 1 spacecraft hardware deliveries and assembly will be completed late in the quarter. The flight 2 spacecraft hardware deliveries and assembly will be completed early in the second quarter. System testing of the two flight spacecraft, including the system level flight acceptance vibration and thermal vacuum testing, will begin in the second quarter and continue into the third quarter. The proof test model spacecraft will be shipped to Cape Canaveral Air Force Station, Florida, to support pathfinder operations early in the third quarter and to provide flight spacecraft subsystems spares. Operations at the Cape with the two flight spacecraft will be initiated midway through the third quarter. Final assembly, systems test, and preparation for launch will be completed and launch will be carried out during the fourth quarter.

Science - Activity will focus on the fabrication, assembly and test of flight instruments and support of system testing in preparation for launch. Support of flight trajectory selection and flight sequence development will continue.

Mission Operations - Major emphasis in FY 1977 will be devoted to implementation of ground data systems required for launch, integration and verification of those systems, training of operations personnel, and the start of actual operations support. In addition, the design of systems to provide planetary encounter capabilities will be continued.

BASIS OF FUND REQUIREMENTS:

Pioneer/Helios

	1975	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
			(Thousands of Dollars)			
Pioneer Venus	26,916	57,600	56,600	15,300	15,300	42,800
Pioneer 6-11	5,326	3,900	3,900	900	900	3,700
Helios A & B	1,400	1,100	1,200	100	200	900
Total	33,642	62,600	61,700	16,300	16,400	47,400

Pioneer Venus

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Spacecraft	18,716	31,400	33,900	8,000	7,200	21,800
Science	7,500	17,000	16,200	4,100	4,900	10,900
Operations	300	2,400	1,900	1,200	1,200	5,400
Project management	400	6,800	4,600	2,000	2,000	4,700
Total	26,916	57,600	56,600	15,300	15,300	42,800
Atlas Centaur (Expendable Launch Vehicles Program)	(400)	(400)	(6,400)	(6,400)	(3,700)	(16,100)

OBJECTIVES AND STATUS:

There are two complementary missions in the Pioneer Venus Project: a multi-probe mission and an orbiter mission. These missions are designed to investigate the atmosphere of Venus and to perform scientific investigations of other aspects of the Venusian environment. Achievement of the primary goal of these missions, which is to determine the nature, dynamics, and evolution of the Venusian atmosphere, should also materially aid in understanding the dynamic processes which are taking place in our own Earth atmosphere. These missions will also determine the relative abundance of the constituents of the Venusian atmosphere and the mass properties of the planet, which will provide data to help understand the origin and evolution of the solar system.

The Hughes Aircraft Company was selected as the Pioneer Venus contractor in February 1974. Detailed design, which was begun in December 1974, is now well along. The final systems design review is scheduled for April, 1976. Development tests are in progress on the multi-probe pressure vessels which are designed to protect the science instruments from the one hundred atmospheres of pressure and high temperatures to be encountered near the Venusian surface. Parachutes to float these instrument containers down through the atmosphere are also being tested. Fabrication of thermal and structural test models of the orbiter and multi-probe spacecraft is in progress, with testing scheduled to start in March, 1976, and to continue through the Transition Quarter and into early FY 1977. For some structural components where design changes are unlikely, flight hardware has already been fabricated. Cost saving approaches to design, procurement,

and testing have been incorporated in the program. These include the utilization of identical subsystems, wherever possible, in the orbiter, probe bus, and probes; the utilization of flight proven designs in approximately forty percent of the subsystem units; and a centralized electronic parts procurement for all science instruments.

The design and development of the scientific experiments is progressing well. All instrument contracts have been awarded, and hardware procurement has begun. Preliminary design reviews of the instruments have been completed, and final design reviews will begin near the end of FY 1976 and continue through the early part of FY 1977.

CHANGES TO BUDGET ESTIMATES:

The decrease in FY 1976 reflects the reprogramming of $1.0 million to the Space Telescope, consistent with provisions in the Committee of Conference report on FY 1976 appropriations. Changes within project elements reflect the transfer of some tests to the prime contractor, increases in contractor wage and benefit scales and overhead rates, and some minor delays in science instrument electronic parts procurement.

BASIS OF 1977 ESTIMATES:

In FY 1977, structural and thermal testing of the total spacecraft system will be completed. All structural fabrication of flight hardware will be completed, and all subsystem unit hardware will be fabricated and tested. The flight probes will be assembled and tested, including the systems for decelerating the probes during atmospheric entry. Buildup of both the orbiter and multi-probe spacecraft will be completed, including probe installation on the probe bus.

Final science instrument design reviews will be conducted, and instrument test units will undergo design verification tests with the spacecraft simulator. Flight instruments will be fabricated, tested, and installed in the various spacecraft. Initial system performance testing will be conducted, and system level environmental testing will commence.

FY 1977 funds will also support the design of the mission operations system and the development of operational software. Compatibility tests with the Deep Space Network will be conducted, and the interplanetary and encounter trajectory analysis will be completed.

Pioneers 6-11

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Spacecraft	210	---	---	---	---	---
Science	2,503	2,585	2,585	600	600	2,400
Operations	2,613	1,315	1,315	300	300	1,300
Total	5,326	3,900	3,900	900	900	3,700

OBJECTIVES AND STATUS:

Pioneers 6-9 are still operational in heliocentric orbits and continue to provide data on solar activities and events as they are propagated through the interplanetary medium. Pioneer 10 was launched on March 2, 1972, encountered Jupiter in December 1973, and is now on its way out of the solar system. Pioneer 11 was launched on April 5, 1973, encountered Jupiter in December 1974, and has been retargeted to encounter Saturn in September 1979. Both Pioneers 10 and 11 are operating satisfactorily, although some instruments have failed or degraded since passing Jupiter. These spacecraft continue to return data on the propogation of the solar wind through the interplanetary medium, and the Saturn encounter will provide information which will significantly affect scientific and trajectory strategies for the Mariner Jupiter/Saturn mission.

BASIS OF FY 1977 ESTIMATES:

During FY 1977, flight operations will continue on all Pioneer spacecraft. Pioneers 6-9 will be supported to the extent allowed by the availability of the DSN tracking network. Pioneers 10 and 11 flight operations will continue, as will data analysis on all returned flight data.

			HELIOS			
Science	755	750	850	75	160	690
Operations	645	350	350	25	40	210
Total	1,400	1,100	1,200	100	200	900
Titan/Centaur (Expendable Launch Vehicle Program)	(7,900)	(400)	(1,500)	---	---	---

OBJECTIVES AND STATUS:

Helios is a two-mission, cooperative effort with West Germany to investigate interplanetary space close to the Sun. The spacecraft, developed and built in West Germany utilizing consultants from the United States, weighs about 370 kg. (800 lbs.) and carries about 55 kg. (120 lbs.) of scientific instruments. Three of the ten instruments are supplied by U.S. investigators. NASA also supports two other experiments and provides the launch vehicles and tracking and data support. West German personnel conduct the spacecraft operations, operate the tracking systems, and acquire the data once initial launch operations have been completed.

Helios A was launched in December, 1974, into a heliocentric orbit which brings it to within .3 Astronomical Units (A.U., defined as the distance between the Earth and the Sun) of the Sun. This spacecraft has now completed two perihelion passes, in March and September, 1975. Preliminary results show that there is much more structure in the magnetic fields and energetic particles close to the Sun than has been previously observed from Earth. The particle streams must, therefore, come from many smaller regions of the Sun rather than a few, larger regions. Data has also been obtained from the zodiacal light and interplanetary dust experiments, and scientists are engaged in analysis and interpretation of these data.

Helios B, which will be invented relative to Helios A, was launched on January 15, 1976, and will spend approximately two weeks in reorientation maneuvers and spacecraft and instrument verification checks before commencing normal operations.

CHANGES TO BUDGET ESTIMATES:

The increase of $100 thousand in both FY 1976 and the Transition Quarter reflects the extension of the successful Helios A mission. Through this extension, it will be possible to make correlative measurements of phenomena in the near-solar environment, gaining new insights into processes and mechanisms of the propagation of solar winds throughout the interplanetary medium.

BASIS OF 1977 ESTIMATES:

Funds requested will support the U.S. portion of project operations and the analysis of data collected by the U.S. experiments.

BASIS OF FUND REQUIREMENTS:

Supporting Research Technology/Advanced Studies

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Planetary science	4,600	4,600	4,600	1,200	1,000	5,200
Planetary advanced studies	1,200	1,200	1,200	300	200	1,200
Planetary advanced technical development	5,200	5,200	5,200	1,300	1,300	5,200
Total	11,000	11,000	11,000	2,800	2,500	11,600

OBJECTIVES AND STATUS:

The Supporting Research and Technology and Advanced Studies programs form the base from which flight programs can be developed. From basic theoretical and laboratory research and advanced studies, science objectives and mission concepts are defined. Instrument development and advanced technology tasks provide for technological readiness for new flight missions. These efforts are being continued to meet these vital objectives.

Planetary Science

4,600	4,600	4,600	1,200	1,000	5,200

OBJECTIVES AND STATUS:

This program is sub-divided into two major areas of research, planetary atmospheres and planetary geology. Both programs conduct basic theoretical and laboratory research, instrument development, and correlative and field studies to prepare for future missions and to understand the basic structure, composition, evolution, and dynamics of planetary atmospheres and bodies.

CHANGES FROM BUDGET ESTIMATES:

The Transition Quarter decrease of $200 thousand reflects adjustments required as part of the general Congressional reduction in NASA's R&D budget request for this period and will necessitate a slowing of some instrument development and research tasks.

BASIS OF FY 1977 BUDGET ESTIMATES:

Development of instrumentation for future planetary missions will continue during this period. Instruments being developed include advanced infrared and ultraviolet spectrometers, high resolution visual imaging instruments, X-ray diffractometers, and seismometers. These instruments will be designed to provide remote sensing information from future planetary flybys and orbiters, and for in situ measurements with future planetary probes and landers.

Laboratory research will be conducted in areas of properties of atmospheric gases such as light scattering and ionization, spectroscopy techniques, and wind erosion and deposition under simulated Martian conditions, to name only a few. Theoretical studies will be conducted on atmospheric turbulence, seasonal variations in atmospheric behavior and planetary polar caps, radiative and connective energy transfer mechanisms, volcanism, and modeling techniques. Field studies will be conducted in desert regions, such as the southwestern United States and Peru, to correlate Earth phenomena with those observed on Mars. Similar studies on impact craters, permafrost, and volcanic processes will be conducted in Europe, Hawaii, and the Arctic to find similarities and differences with data returned from the Moon, Mars, and Mercury. All of these activities will contribute to our knowledge of the mechanisms and processes which have created and continue to alter the solar system and our own planet.

Planetary Advanced Studies

1975	1976		Transition Quarter		1977
Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)			
1,200	1,200	1,200	300	200	1,200

OBJECTIVES AND STATUS:

The objective of the advanced studies project is to provide the basis for the systematic exploration of the solar system. Prospective planetary missions are identified and defined through a process which includes conducting mission concept definition and feasibility studies; identifying new mission opportunities (e.g. multiple planet flybys); and developing implementation schedules, science objectives, and resources requirements. These missions may then be evaluated in terms of technological readiness, resources requirements, and scientific merit to select those most promising for further study and detailed definition. These advanced studies are performed both under contract and in NASA Centers, and they encompass a range from mission analysis and system feasibility to preliminary mission design and engineering. Only through these studies can a logical, timely, and cost-effective posture with regard to solar system exploration be maintained.

CHANGES FROM BUDGET ESTIMATES:

The reduction of $100 thousand in the Transition Quarter reflects adjustments required to absorb part of the Congressional reduction in NASA's R&D budget request for this period. Planned study efforts on Venus-Earth gravity assist trajectories and comet missions will be reduced in scope to make this adjustment.

BASIS OF FY 1977 ESTIMATES:

The FY 1977 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 Transportation System.

Missions to be studied include the following: a Lunar Polar Orbiter with remote geochemical sensing capabilities; a Mercury Orbiter that is derived from the Lunar Polar Orbiter; a Venus Orbiter with synthetic aperture coherent radar to image and map the surface of Venus; a Jupiter Orbiter to perform detailed studies of the spatial and temporal variations of the Jovian magnetosphere and atmosphere; and a Jupiter swingby out-of-the-ecliptic mission that will provide a third dimension to all previous studies of the Sun and the interplanetary/interstellar medium.

Planetary Advanced Technical Development

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
5,200	5,200	5,200	1,300	1,300	5,200

OBJECTIVES AND STATUS:

The Advanced Technical Development (ATD) program supports the planning 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 1976 the major areas of emphasis are the development of outer planet probe and orbiter technologies, the determination of the technological and scientific feasibility of a Mars penetrator mission, and the development of an extended capability infrared spectrometer optimized for use in the environment beyond Saturn. In addition, advanced development of several technologies with multimission applications is underway. This effort includes the completion of work on an improved transponder, continuing development of imaging systems utilizing charge coupled device sensors, and work on an advance star tracker with reliability and lifetime characteristics suitable for future long duration missions. Long term life testing of propellants with various propulsion system materials and techniques for navigation with solar electric propulsion are also being continued. Work on outer planet technologies and Mars penetrators will continue through the Transition Quarter.

BASIS FOR FY 1977 ESTIMATES:

During FY 1977 emphasis will be placed on the extension of outer planet probe and orbiter related effort fo. future missions. In the probe area, the Pioneer Venus probe will provide major technological input to the study of an outer planet probe. Supporting these studies will be tasks to assure technological readiness in a number of critical areas. For the orbiter, these tasks will include radiation hardening, imaging, space-

craft charging, and mission analysis and navigation techniques for multiple satellite encounters. In support of the probe studies, additional effort will be devoted to techniques for adapting certain Pioneer Venus science instruments to Jupiter entry measurements and evaluating the feasibility of incorporating pre-entry science into the probe. Other areas requiring further study include entry communications, probe power supply, and thermal protection.

Additional major activities will include the continuation of the Mars penetrator tasks and study efforts for Comet Encke and Lunar Polar Orbiter missions. The Lunar Polar Orbiter mission definition will continue, leading to a preliminary spacecraft design incorporating experiments selected from those already proposed in response to an Announcement of Opportunity. A science team composed primarily of experiment Principle Investigators will provide guidance so that planning for the mission will reflect maximum science return.

BASIS OF FUND REQUIREMENTS:

Planetary Data Analysis

1975	1976		Transition Quarter		1977
Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)			
1,628	1,400	1,400	400	400	2,500

OBJECTIVES AND STATUS:

This project encompasses the post-project analysis and interpretation of the wealth of data obtained from previous planetary flight programs. Interdisciplinary correlation studies of the results from past Mariner and Pioneer flights, as well as Earth-orbital satellites such as the Atmosphere Explorers, continue to insure the maximum science return from these previous flights. Atmospheric scientists concentrate their efforts in the fields of atmospheric composition, structure, and dynamics, while planetological analysts concentrate on geologic structure, composition, and dynamics.

During FY 1976 and the Transition Quarter, the geologic mapping of Mars will be completed and will represent the efforts of over forty different cartographers. Comprehensive analysis of Pioneer 10 and 11 and Mariner 10 data has been initiated to gain insights into the circulation and properties of the atmospheres of Venus and Jupiter, and Jovian magnetospheric dynamics.

BASIS OF FY 1977 ESTIMATES:

During FY 1977, these activities underway in FY 1976, and others of a similar nature, will continue, with emphasis on recent data acquired from Mercury, Venus, and Jupiter. Terrain features and characteristics found on Mars and Mercury will be correlated to shed light upon the fundamental geologic processes involved in planetary evolution. Geologic and topographic mapping of Mercury will build up significantly in FY 1977. For the first time, comparable data from Earth, the Moon and two other terrestrial planets can be subjected to intensive correlative analysis. Atmospheric studies will continue to delve into circulation patterns and their change, atmospheric structure and composition, and the dynamics and mechanisms of the atmospheric, magnetospheric, and solar wind interactions characteristic of each of these visited planets.

BASIS OF FUND REQUIREMENTS:

Planetary Astronomy

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
4,200	4,200	4,200	1,100	900	4,800

OBJECTIVES AND STATUS:

This 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.

Through these research efforts, astronomers and other scientists located at NASA centers, universities, and observatories contribute their results which both supplement and complement flight programs. All of the above activities are closely coordinated with the National Science Foundation.

Significant accomplishments during the past year include the radar mapping of Venus, radar studies of the Viking landing sites, radar detection of the Galilean satellites of Jupiter, and other endeavors related to the support of flight programs. Important discoveries were made in the Jovian system with the detection of carbon monoxide on Jupiter and the detection of a potassium cloud around Io, one of the Galilean satellites.

CHANGES FROM BUDGET ESTIMATES:

The Transition Quarter reduction of $200 thousand reflects adjustments necessary to accommodate part of the general Congressional cut in NASA's R&D budget request for this period. The decrease resulted in a reduced level of support for optical and radio astronomy tasks.

BASIS OF FY 1977 ESTIMATES:

In FY 1977, the program of astronomical research tasks supporting the planetary flight program will be continued. These data aid in the design of spacecraft and the selection of flight experiments for the greatest potential information return. In addition, the funding covers requirements for partial operational costs of the Arecibo Observatory, to continue a planetary radar prpgram using the high-power radar system at the Observatory.

Increased funding in FY 1977 reflects the planned operational support of the new infrared telescope facility under construction at Mauna Kea, Hawaii. This new facility will provide scientific data needed to support planetary missions to the outer planets, such as Mariner Jupiter/Saturn. In FY 1977 emphasis will be placed on studies of the outer planets with the accent on infrared and continuing radar observations of Satrun's rings, the Galilean satellites, and some asteroids. Radar studies of Venus will be continued.

BASIS OF FUND REQUIREMENTS:

Planetary Flight Support

1975	1976		Transition Quarter		1977
Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)			
24,725	29,300	29,200	8,800	8,700	27,900

OBJECTIVES AND STATUS:

The integrated computing and computer-related activities which support the general tracking, telemetry, and command functions for all planetary automated spacecraft during test, training, and flight are funded through Planetary Flight Support. These funds also support the general purpose scientific and engineering computing at the Jet Propulsion Laboratory (JPL), and selected project-peculiar activities such as preparation of data records, computer analysis time, and provision for the mission support areas.

Fiscal Year 1976 and Transition Quarter funds are being used to support Pioneers 6 through 11, with Pioneer 11 on its way to a Saturn encounter; the continuing operations of the Helios A mission; the Helios B launch in January 1976 and subsequent flight operations; the Viking 1 and 2 launches and cruise operations; and the continuing preparation for support of the two Mariner Jupiter/Saturn launches in 1977.

CHANGES FROM BUDGET ESTIMATES:

Minor reductions of $100 thousand in FY 1976 funding resulted from leasing rather than purchasing some peripheral equipment to support the extension of the Helios A mission. As part of the general reduction imposed by the Congress for the Transition Quarter, minor deferrals amounting to $100 thousand were made in planned equipment purchases.

BASIS OF FY 1977 ESTIMATES:

During FY 1977, funds will be used to continue support of Pioneers 6 through 11, the Helios A and B missions, the Viking 1 and 2 missions, the launch and subsequent operations of the two Mariner Jupiter/Saturn spacecraft, and the planning and implementation required to support Pioneer Venus. The implementaion of the new distributed mini-computer approach to mission support will also be completed.

Additional activities which will be supported from these funds include the following: support of the tracking system analytic calibration effort; formulation of planetary programs data systems standards; management of the Operations Support Coordinating Office at JPL which concentrates on system analysis and design, and support of projects not managed at JPL; investigation of cross-support utilizing other NASA or non-NASA computer capability.

BASIS OF FUND REQUIREMENTS:

Lunar Research Program

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Lunar science	4,701	4,700	5,100	1,300	1,200	3,200
Lunar data analysis and synthesis	6,985	9,600	8,950	2,300	1,600	9,000
Lunar science operations	4,420	4,800	5,050	1,100	1,100	5,000
Lunar sample analysis	5,798	5,600	5,600	1,400	1,200	5,200
Total	21,904	24,700	24,700	6,100	5,100	22,400

OBJECTIVES AND STATUS:

Interdisciplinary interpretation, intensive analysis, laboratory research, and ground-based observations continue in the lunar programs, to thoroughly digest the large and growing body of data on the Moon. Through these efforts new insights into observed phenomena and new theoretical bases explaining them are derived. Work already accomplished has fostered new and revolutionary theories on the structure and history of the Moon and will continue to make significant contributions to our knowledge of the formation and dynamics of other bodies. Integration of lunar and planetary data and the use of similar analytical techniques to study these data will lead to a better understanding of the origin, history, and present characteristics of the solar system.

Lunar Science

4,701	4,700	5,100	1,300	1,200	3,200

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 program is presently the only source of significant new lunar data. These activities emphasize studies in Earth-based observations, analog studies, theoretical studies, laboratory simulations, and meteorite 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, acting as a portal to the outside scientific community, serves as an important data repository facility open to all qualified scientists and enables these scientists to utilize the extensive array of scientific equipment at JSC. In addition, occasional preliminary mission studies for potential lunar flight programs are supported herein.

CHANGES FROM BUDGET ESTIMATES:

The increase of $400 thousand in the FY 1976 budget estimate reflects the heavy use of the National Space Science Data Center (NSSDC) by lunar investigators which required increased levels of support. The Transition Quarter reduction of $100 thousand reflects the deferral of some new theoretical and laboratory efforts as a result of adjustments necessary to accommodate the general Congressional reduction in NASA's R&D budget request for this period.

BASIS OF FY 1977 ESTIMATES:

Fiscal Year 1977 funding is required for continued support of lunar science laboratory and ground-based efforts, including telescopic observations, and Lunar Science Institute and NSSDC activities. Some initiatives will be undertaken in geodynamics and related Earth sciences to use the lunar data base to gain insights into general planetary formation and evolution.

Lunar Data Analysis and Synthesis

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)			
6,985	9,600	8,950	2,300	1,600	9,000

OBJECTIVES AND STATUS:

The objectives of this work are the continued interpretation of the large and still growing body of data acquired by lunar missions and continuing research, and, through the integration of these results, the enhancement of our knowledge of the origin, present characteristics, and history of the Moon. Synthesis of these lunar data with those of terrestrial, planetary and solar studies contributes to the overall program objectives.

During the Apollo flight phase of the lunar 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 prior automated lunar flight programs now requires a major program of interdisciplinary analysis and synthesis which will provide the major scientific payoff 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 origin and history.

CHANGES FROM FY 1976 AND TRANSITION QUARTER BUDGET ESTIMATES:

The $650 thousand reduction in the FY 1976 estimate reflects the reprogramming of funds to support the increased usage of the NSSDC by lunar investigators. Additional transfers were made to support the development of a portable Lunar Laser Ranging Station which will extend the geophysical measurements now being made at the two fixed Lunar Laser Ranging sites in Texas and Hawaii.

The Transition Quarter reduction of $700 thousand reflects a share of the Congressional reduction of the NASA budget for this period. This reduction was accomplished by deferral of some tasks to FY 1977.

BASIS OF FY 1977 ESTIMATES:

The activities of the nearly 100 Principle Investigators supported by this program continue to enlarge as more types of data are used in their efforts to understand the Moon and to apply this knowledge to the Earth and other planets. 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 an increasing science return at a relatively constant funding level.

Lunar Science Operations

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
4,420	4,800	5,050	1,100	1,100	5,000

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 retroreflectors 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 sixth anniversary of continuous operation on November 19, 1975.

Many of the experiments are still furnishing valid scientific information; no degradation of the retroreflectors has been detected. We will continue to operate these 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 require support at Johnson Space Center (JSC) to operate these instruments and to record and format raw data, to support investigator reduction of the raw data from these instruments to useful scientific observations, and to place these data in data banks where they will be available to all responsible scientific investigators.

The Sample Curatorial Facility at Johnson Space Center and the Sample Remote Storage Facility at Brooks Air Force Base are major components of the post-Apollo scientific effort. The Curatorial Facility operation involves support at JSC for handling, storing, preparing, and distributing lunar materials; documenting the history and data obtained on each sample; and assuring sample security. Although the Remote Storage Facility's primary purpose is the long-term, secure storage of a part of the sample collection, some circulation of sample material does take place between the Curatorial Facility and the Remote Storage Facility. This circulation activity involves support at JSC for preparing and documenting the samples prior to transfer to remote storage and the small costs of the transfer operations. 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 BUDGET ESTIMATES:

The increase of $250 thousand in the 1976 budget estimate reflects the initiation of work on a portable lunar laser ranging station, which will make geodynamics measurements complementing the measurements at the existing fixed sites in Texas and Hawaii, and the installation of geophysical instrumentation at the two fixed sites.

BASIS OF FY 1977 ESTIMATES:

During FY 1977 the lunar laser ranging program will continue at both McDonald Observatory and Mt. Haleakala. With the two stations producing range data, analysis will continue to develop new information on the dynamics of the Earth-Moon system. The primary objectives include the study of gravitation and relativity and of the physics of Earth and Moon. Significant benefits that will increase our understanding of Earth are more accurate measurements of the wobbles of 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, providing data on continental drift.

Continued support to the operating ALSEPs, the Sample Curatorial Facility, and the Sample Remote Storage Facility will also be provided during this period. It is currently planned to improve the present Curatorial Facility in order to provide increased capacity for handling these irreplaceable materials safely, permitting future experiments which are not now possible.

Lunar Sample Analysis

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
5,798	5,600	5,600	1,400	1,200	5,200

OBJECTIVES AND STATUS:

The purpose of this activity is to understand better the nature, origin, and history of the Moon by analyzing lunar samples for the unique information they contain. Previous studies of lunar samples have provided otherwise unobtainable data about the chemical composition, age, and early history of the Moon. Now the study of lunar samples is shifting from its early emphasis on data collection to a more sophisticated concentration on lunar investigations and to the use of new analyses to test specific theories about the Moon.

One major area of current effort involves such topics as the history and origin of mare basalts, the history of the Moon before four billion years ago, the effects of meteorite impacts on the lunar surface, the discovery of unusual lunar rock types such as dunite and granite, and the re-examination of specific lunar samples in the light of new data.

A second research area, just emerging, is the use of lunar samples as unique records of the Moon's space environment. For billions of years, the lunar rocks and soil have been exposed to cosmic dust, streams of atoms boiled out of the Sun, and cosmic rays; much current scientific effort is aimed at deciphering this record of the behavior of our universe. Studies of tiny microcraters on the surfaces of lunar rocks are yielding information about the distribution of cosmic dust in space and time. Scientists are also starting careful examination of the samples of lunar soil layers that were collected in core tubes; these soil layers provide a history of solar flares, meteorite impacts, and the evolution and mixing of the lunar soil.

CHANGES FROM BUDGET ESTIMATES:

The reduction of $200 thousand in the Transition Quarter estimate is the Lunar Sample Analysis share of the overall Congressional cut in NASA's R&D budget request for this period. This reduction will require delay in the initiation of some new tasks.

BASIS OF FY 1977 ESTIMATES:

During FY 1977, investigations of lunar samples will be carried out by about 135 Principal Investigators, of whom about 25 are foreign scientists whose activities are supported entirely by their own governments. The total effort involves about 700 scientists, and many of the studies apply unique analytical techniques and capabilities that represent the highest degree of current technology.

This large number of scientific teams is essential for continued progress; the study and interpretation of lunar samples bring together an unusually wide range of formerly separate scientific disciplines, such as geology, mineralogy, geophysics, nuclear physics, solar astronomy, and high-energy astronomy. The present group of scientists provides the broadly based scientific effort needed to obtain the maximum possible amount of information from the lunar rocks.

The facilities supported for research on lunar samples also constitute an important national scientific resource. The unique instrumental techniques and procedures originally developed for lunar sample analysis have now been applied to other fields, such as meteorite research, terrestrial geology, and organic geochemistry. As a result, important new information has been obtained about the development of life on our own planet, the origin of the solar system, the origin of terrestrial volcanic lavas, and the ancient history of the Earth. The information and experience obtained by analyzing lunar samples have also greatly increased

our capabilities to capitalize upon future planetary exploration using unmanned spacecraft for remote sensing or return of small surface samples.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1977 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

LIFE SCIENCES PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Space life sciences	15,000	16,000	16,000	4,750	4,300	17,325
Planetary biology	3,300	3,300	3,300	800	600	3,300
Planetary quarantine	1,500	1,500	1,500	400	300	1,500
Total	19,800	20,800	20,800	5,950	5,200	22,125
Distribution of Program Amount by Installation:						
Johnson Space Center	5,798	5,600	5,800	1,700	1,840	6,000
Kennedy Space Center	18	---	100	---	---	1,000
Marshall Space Flight Center	853	2,000	500	575	115	---
Goddard Space Flight Center	---	---	---	---	---	500
Jet Propulsion Laboratory	1,426	1,400	1,500	350	335	2,100
Ames Research Center	7,991	8,475	8,347	2,475	1,650	8,375
Flight Research Center	106	75	100	---	---	100
Langley Research Center	50	---	---	---	---	---
Headquarters	3,558	3,250	4,453	850	1,260	4,050
Total	19,800	20,800	20,800	5,950	5,200	22,125

OFFICE OF SPACE SCIENCE — LIFE SCIENCES PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The main objectives of the Life Sciences program are the following: (1) to provide access to space to scientists and other personnel without special flight training; (2) to enhance people's capabilities to work efficiently in space, (3) to carry out a strong scientific program in space by developing experiments and facilities to be flown on Shuttle/Spacelab missions, (4) to prepare for long-duration manned space flight by research in medical and environmental control systems, and (5) to support NASA efforts in the search for extraterrestrial life.

The Life Sciences program is multifaceted and interdisciplinary in both its content and approach to these objectives. Research and development programs in space life sciences (life support and protective systems, bioinstrumentation, and human machine technology), planetary biology and planetary quarantine have been conducted and will be continued as essential to furthering the accomplishment of these objectives.

Space flight is an important and useful biological research tool. Unique aspects of the space environment, such as radiation and the absence of gravity, can be studied only in space flight. It is anticipated that the Life Sciences flight experiment plan in the Space Shuttle/Spacelab Program will use the unique gravity-free environment to study basic biological processes such as cell division and metabolism, embryonic induction and morphogenesis, plant geotropic responses, and physiological responses of humans and animals.

The knowledge gained and the technology developed during the course of Life Sciences research are made available to the scientific and technical community for applications and the advancement of scientific research, education, and technology. Many of these advances in bioinstrumentation, life support and protective systems, and human machine technology have been made available to the public from the research and development program through the technology utilization program. The medical and biological research conducted in support of manned space flight has added a new dimension to the understanding of normal human physiology and human responses to the stresses associated with space flight. Another aspect of the Life Sciences program objectives is the continued involvement in the international scientific community. Of special significance is the exchange of life sciences information of mutual interest with the U.S.S.R. The joint working group meetings with the U.S.S.R. resulted in the flight of four NASA Life Sciences experiments in the Russian-launched biosatellite (KOSMOS 782), in November 1975. This successful effort forms the basis of the current planning by the NASA Life Sciences program for the flight of additional experiments in 1977, on the next planned launch of a U.S.S.R. dedicated biosatellite.

The Life Sciences program is heavily involved in supporting the Space Shuttle/Spacelab medical activities, including developing new medical standards and selection criteria for the scientist/passenger. A major objective in support of this program will be achieved with the Life Sciences Payload program being designed and developed to be flown during the Shuttle era. These efforts, in conjunction with the Life Sciences involvement in the preliminary design of manned orbiting space station concepts and the associated activities planned for these future systems, help to focus the Life Sciences research in support of long duration manned space flight.

The funding requested for Fiscal Year 1977 provides for the continuation of the on-going program, and the initiation of development activities in the Vestibular Function Research program.

BASIS OF FUND REQUIREMENTS:

Space Life Sciences

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Space life research	8,900	8,900	8,900	2,400	2,550	10,675
Life support and protective systems	3,000	3,000	3,000	750	750	2,250
Bioinstrumentation and human machine technology	3,100	3,100	3,100	1,150	500	2,000
Life sciences Spacelab payloads common operating research equipment (CORE)	---	1,000	1,000	450	500	1,500
Vestibular function research	---	---	---	---	---	900
Total	15,000	16,000	16,000	4,750	4,300	17,325
		Space Life Research				
	8,900	8,900	8,900	2,400	2,550	10,675

OBJECTIVES AND STATUS:

Space Life Research activities focus on ground-based and space flight research designed to enhance the ability of people to function effectively and safely during space flight, and to conduct research, using the

unique environment of space, to support and advance earth-based life sciences. This multidisciplinary research program encompasses medical, behavioral, and biological earth-based research, as well as the definition of space flight biomedical experiments. The primary objective is to maintain a research base investigating all pertinent aspects of known and anticipated problems concerned with the adaptation of humans to the space flight environment and to provide rapid response to new problems that arise.

As a result of the carefully controlled biomedical experiments performed during the Skylab missions, specific areas of research were identified as requiring additional emphasis. The FY 1976 program reorganized the research base to more effectively focus upon these specific areas of interest, which included such problem areas as cardiovascular deconditioning, space motion sickness, bone/muscle changes, blood changes, and fluid and electrolyte changes. In addition, physiological and psychological criteria are being developed for use in the selection of crew members and scientist passengers for the Space Transportation System missions.

CHANGES FROM BUDGET ESTIMATE:

Transition Quarter Estimate: The increase of $150 thousand reflects the increased studies of biospheric effects of the Space Shuttle, particularly in the area of solar ultraviolet changes to stratospheric ozone.

BASIS OF FY 1977 ESTIMATE:

During FY 1977, emphasis will be placed on ground-based life sciences research related to the Space Transportation System missions. For each specific medical and behavioral problem area, the research will emphasize the identification and study of basic mechanisms involved in the Zero-g adaptation process and in the investigation and development of operational countermeasures or methods to facilitate the adaptation process, including training/conditioning/exercise techniques and drugs. In support of these efforts, humans and small animals will be subjected to various stress environments, such as bed rest, parabolic aircraft flights, and centrifugation. These tests will be conducted to investigate responses such as semicircular canal and otolith organ interaction and their relation to vertigo and motion sickness; body fluid shifts and the effects on various body functions; and loss of calcium and the structural integrity of bone under conditions of disuse or loss of gravitational forces. FY 1977 funding will also provide for the definition and evaluation of animal and plant experiments to be flown on Shuttle/Spacelab missions.

Life Support and Protective Systems

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
3,000	3,000	3,000	750	750	2,250

OBJECTIVES AND STATUS:

The objectives of the Life Support and Protective Systems efforts are to enhance the performance capabilities and insure the safety and well-being of passengers and crew of future spacecraft. These will be accomplished by continued research and development of improved life support and safety (crew protective) equipment. Improved reliability, maintainability, and operational characteristics are key goals in these efforts.

Programs for development of electrochemical carbon dioxide removal and concentration are being pursued, with the objective of providing both continuous removal capability (prior efforts, as represented by the Skylab molecular sieve system were cyclic in operation) and efficient carbon dioxide removal at low concentrations. Similar principles are being applied to the investigation of oxygen concentrators in order to establish the capability to refill high pressure oxygen supply bottles for EVA and emergency use without the use of mechanical pumps for oxygen, a difficult and potentially dangerous undertaking. An improved method of controlling atmospheric contaminants is also being investigated using a catalyst-impregnated charcoal which can be regenerated by periodic oxidation of the absorbed contaminants within the charcoal bed. Improved water reuse technology is under active investigation, especially in the use of newly developed membranes wherein, through reverse osmosis and ultrafiltration systems, waste waters such as wash water and humidity condensate, as well as human wastes, can be purified for reuse. Work is continuing on the advanced liquid-cooled garment, emphasizing comfort and durability as well as high thermal conductivity materials and close contact with large areas of the human body. Investigations are in progress into the use of scratch-resistant coatings for plastics which promise to provide abrasion-resistant coatings for astronaut helmets and visors. This process is also under investigation by Technology Utilization personnel, utilizing this process to protect plastic lenses used for correcting visual defects.

BASIS OF FY 1977 ESTIMATE:

The FY 1977 Life Support and Protective Systems efforts, in addition to continuing the research initiated in FY 1976, will emphasize several areas which are seen as most important for future manned spacecraft: investigation of a new carbon dioxide reduction process operating at substantially reduced temperatures;

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initiation of efforts to study and demonstrate better means of sensing and controlling regenerable life support systems for future spacecraft, incorporating operational status, and caution and warning indicators that will enhance human capability to monitor and maintain these complex systems in space; and initiation of studies of biological (plant) systems for nutritional supplements in space and as sources of oxygen for the crew in closed ecological systems, studies that are a prerequisite to future closed systems capability.

Bioinstrumentation and Human Machine Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
3,100	3,100	3,100	1,150	500	2,000

OBJECTIVES AND STATUS:

Bioinstrumentation and Human Machine Technology is concerned with the development of instruments for the measurement of the medical and physiological status of humans and human surrogates, the design for and augmentation of human capabilities, and the development of health care delivery systems in the space environment.

Bioinstrumentation advances in FY 1976 include the completion of a biowaste monitoring system for measurement and analyses of human waste products. A protoflight hardware design of a carry-on unit that can be plugged into the Space Shuttle waste management system is being fabricated. Development of a multidimensional ultrasonic heart size and volume measurement and display device is continuing. The STARPAHC ground-based study of space-oriented health care delivery system is in the operational phase and will continue through the current fiscal year.

In the human machine technology areas, habitability features required for efficient living and working in space are being developed. Although the results of this research are applicable to the Space Shuttle Orbiter mid-deck design, the information will also be applicable to all future manned space vehicles where volume and crew quarter configurations are severely limited. Existing anthropometric data are being compiled into a single reference document for design of space vehicles such as the Space Shuttle and Spacelab where male and female scientists and investigators will conduct flight experiments and related activities.

Teleoperator technology advancements in FY 1976 will include the improved design of a stereo viewing system with a three-dimensional display at the operator's console, using a single Fresnel lens system. Additional effort is underway on the development and incorporation of proximity sensors for use on the end of manipulator arms for control of end effectors from remote sites. Voice controllers will be added to manual control of manipulators, to study their feasibility and effectiveness.

CHANGES FROM BUDGET ESTIMATE:

Transition Quarter Estimates: The decrease of $650 thousand reflects adjustments resulting from the overall Congressional reduction in NASA's R&D budget request for the Transition Quarter. These adjustments necessitiated reevaluation and reduction of the developmental work in Advanced Teleoperator Systems for extravehicular activity originally planned for this period.

BASIS OF FY 1977 ESTIMATE:

In FY 1977, the bioinstrumentation efforts will emphasize the development of long shelf life reagents for use with the rapid blood analysis in the miniaturized laboratory system, and the improvement of power life and availability of implantable medical measurement units which measure blood pressure and volume inside the bodies of experimental animals. Development of a whole-body bone mineral content measurement system for studies and health status monitoring and maintenance in space will continue.

The human machine technology activities in FY 1977 will be concerned with the development of small dexterous manipulators (arms) and end effectors (hands) that can reach around objects. Proximity and tactile sensors will be used to augment the TV camera visual information for use in areas where the television cameras are not effective, such as tight or dark areas, or where a sense of feel is required. Teleoperator simulation studies to define the most efficient combinations of sensors, arms, and hands for various classes of task performance will continue. Image enhancement methodology will continue, with emphasis on miniaturization of equipment and reduced data transmission requirements.

Common Operating Research Equipment (CORE)

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
---	1,000	1,000	450	500	1,500

OBJECTIVES AND STATUS:

Like the Shuttle Orbiter, the Spacelab will provide scientists with a "shirt-sleeve" environment. For Life Sciences investigations, the laboratory will be outfitted and integrated in modular fashion on racks, with off-the-shelf essential 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.

For many Shuttle missions dedicated to other disciplines, it is estimated that some capability will exist that could accommodate experiments of opportunity. The location could be in the Spacelab, in the Shuttle bay, or in the Orbiter itself. The design approach of modular components of the dedicated labs, plus the simple change capability of equipment instrumentation, has been extended to provide mini-laboratories in several sizes. These mini-labs can handle a few experiments per mission.

During the past year a competitive study effort with two contractors was conducted to provide NASA with preliminary engineering studies of several design and integration concepts for a dedicated Life Sciences Spacelab and to examine other requirements such as mini-labs, ground support hardware, programmatic plans, and cost estimates. The study results were provided in January 1976 and are being assessed.

CHANGES FROM BUDGET ESTIMATE:

Transition Quarter Estimate: Funding was increased by $50 thousand to provide for early release of long lead time flight hardware contracts.

BASIS OF FY 1977 ESTIMATE:

Our plans for FY 1977 are to initiate preliminary design and verification of the best of the concepts identified by the study contracts, and in parallel, to work on the very long lead items. Verification will be accomplished through various short simulations which will mock-up concepts and run real experiments to see if there are defects or problems. An example of a long lead item is the technology for specimen-holding facilities and for biological freezers for on-orbit specimens. In FY 1975-1976 scientists and engineers participated in a requirements definition study to delineate the life support environment required to support specimens in Zero "g", and then engineered the requirements into preliminary designs for use in the CORE. In 1977 we plan to breadboard the most promising concepts and run laboratory tests to validate the approach.

Vestibular Function Research (VFR)

1975	1976		Transition Quarter		1977
Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)			
---	---	---	---	---	900

OBJECTIVES AND STATUS:

The Vestibular Function Research project is a series of flight experiments designed to study vestibular mechanisms, their response to the zero gravity environment, and the ways in which these responses can be modified. It is important that we understand the mechanisms of vestibular response which apparently begin to function upon entry into zero gravity and continue at least until adaptation is complete. What is required is experience and experimentation in the operating force field (zero gravity), in a manner and of sufficient duration to observe the changes through a full adaptation cycle.

Small animals with vestibular systems similar to the human will be flown on a 15-20 day zero gravity mission and compared with a control group on the ground where all test parameters will be duplicated except for zero gravity. The first Vestibular Function Research mission is planned for 1980 Shuttle launch, with retrieval for refurbishment and relaunch with new experiments at approximately 1-year intervals.

During FY 1976, we have been conducting analysis and planning. We have concluded that use of hardware based on minimum modification of an earlier design would be the most cost effective approach. This design requires increased oxygen for the life support and improvement in handling an increased waste content.

BASIS OF FY 1977 ESTIMATE:

In FY 1977, we plan to issue proposals for flight hardware based on the previous flight design and design studies, and to award a contract for its fabrication. The funds will provide for initiation of the development activities and procurement of long lead items.

Planetary Biology

1975	1976		Transition Quarter		1977
	Budget	Current	Budget	Current	Budget
Actual	Estimate	Estimate	Estimate	Estimate	Estimate
		(Thousands of Dollars)			
3,300	3,300	3,300	800	600	3,300

OBJECTIVES AND STATUS:

This program is directed toward producing the answers to fundamental questions about 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 chromotograph to fly on Pioneer Venus is also a product of this program. In addition, work has been initiated on factors 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.

CHANGES FROM BUDGET ESTIMATE:

Transition Quarter Estimate: The decrease of $200 thousand in the current estimate compared with the budget estimate was necessitiated by Congressional action reducing NASA's overall R&D budget request for the transition quarter. The reduction results in deferral of renewal of grants originally planned for this period.

BASIS OF FY 1977 ESTIMATE:

During FY 1977, Planetary Biology will continue to support tasks in approximately 60 universities and the Ames Research Center in the areas of organic chemistry, organic geochemistry, the biology of environmental extremes, and the development of techniques for 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 interpretation of data returned from such investigations.

Planetary Quarantine

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
1,500	1,500	1,500	400	300	1,500

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 (COSPAR). The results of this program are also required for compliance with Article IX of the Space Treaty of 1966.

CHANGES FROM BUDGET ESTIMATE:

Transition Quarter Estimate: The decrease of $100 thousand reflected in the current estimate was necessitiated by Congressional action reducing NASA's overall R&D budget request for the transition quarter. The reduction required deferral of back contamination tasks originally planned for this period.

BASIS OF FY 1977 ESTIMATE:

Planetary Quarantine research in FY 1977 will emphasize studies of the possibility that terrestrial microorganisms can survive, but not reproduce, on extraterrestrial surfaces. Studies of the new environment encountered in outer space that may sterilize spacecraft during transit will be continued. Studies 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 will be supported at a lower level. Studies of the environments of the outer planets and their satellites, as they pertain to the likelihood of survival and growth of terrestrial organisms, will be pursued so that sterilization requirements for such planets can be defined specifically.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1977 ESTIMATES

BUDGET SUMMARY

OFFICE OF APPLICATIONS

SPACE APPLICATIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Earth resources detection and monitoring	58,687	57,730	59,730	14,000	13,900	67,300
Earth dynamics monitoring and forecasting	9,600	8,000	8,000	2,400	2,200	4,600
Ocean condition monitoring and forecasting	15,600	22,800	20,800	6,800	6,500	30,600
Environmental quality monitoring	26,400	24,200	22,200	10,600	9,400	26,100
Weather and climate observation and forecasting	42,073	39,700	42,700	13,200	9,600	36,300
Materials processing in space	4,600	5,300	5,700	1,400	1,200	9,200
Space communications	12,000	8,200	10,000	2,400	1,900	10,600
Information management	3,200	3,200	3,200	1,300	800	3,200
Applications explorer missions	2,588	5,900	5,900	2,600	2,200	10,300
Total	174,748	175,030	178,230	54,700	47,700	198,200
Distribution of Program Amount by Installation:						
Johnson Space Center	32,262	33,030	30,863	9,500	6,934	32,815
Kennedy Space Center	1,227	1,300	710	200	95	700
Marshall Space Flight Center	7,691	6,500	7,225	2,050	2,364	11,155
National Space Technology Laboratories	265	200	543	50	38	548
Goddard Space Flight Center	91,095	86,400	86,889	30,100	25,817	89,953
Jet Propulsion Laboratory	10,549	14,400	15,372	4,500	4,990	28,980
Wallops Flight Center	6,734	9,300	6,430	1,900	1,508	5,542
Ames Research Center	5,980	5,400	7,169	1,600	1,900	8,553
Langley Research Center	9,653	9,300	9,631	2,700	2,838	9,324
Lewis Research Center	2,732	2,500	3,292	400	492	2,732
Headquarters	6,560	6,700	10,106	1,700	724	7,898
Total	174,748	175,030	178,230	54,700	47,700	198,200

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1977 ESTIMATES

OFFICE OF APPLICATIONS

SPACE APPLICATIONS PROGRAM

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Earth Resources Detection and Monitoring:		
Earth Resources Technology Satellites	Launch of LANDSAT-C	1977
Earth Dynamics Monitoring and Forecasting:		
Laser Geodynamics Satellite	Launch of LAGEOS	1976
Ocean Condition Monitoring and Forecasting:		
Ocean Dynamics Satellite	Launch of SEASAT-A	1978
Environmental Quality Monitoring:		
Air Pollution and Oceanographic Observing Satellite	Launch of NIMBUS-G	1978
Weather and Climate Observation and Forecasting:		
Operational Temperature Sounding Satellite	Launch of TIROS-N	1978
	Data Systems Test	1976
Global Atmospheric Research Program	First GARP Global Experiment	1977-79
Materials Processing In Space:		
Sounding Rocket Missions	Launch about 6 annually	
Space Communications:		
Cooperative Applications Satellite	Launch of CAS-C	1976

FLIGHT SCHEDULE

PROJECT	MISSION	CALENDAR YEAR
Applications Explorers:		
Heat Capacity Mapping Mission	Launch of HCMM	1978
Stratospheric Aerosols and Gas Experiment	Launch of SAGE	1979
Matnetic Field Satellite	Launch of MAGSAT	1980
Reimbursable Missions:		
ITOS*	Launch of ITOS E2-I	1976-1978 (Subject to call-up by NOAA)
GOES*	Launch of GOES B and C	1976-1978 (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	1978-1984 (Subject to call-up by NOAA)

* National Oceanic and Atmospheric Administration (NOAA) funded.

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 effective applied and used for down to earth practical benefits. These R&D activities are grouped in the following general areas: Earth Resources Detection and Monitoring, Earth Dynamics Monitoring and Forecasting, Ocean Condition monitoring and Forecasting, Environmental Quality Monitoring, Weather and Climate Observation and Forecasting, Materials Processing in Space, Space Communications, Information Management, and Applications Explorer Missions.

In each of these areas, programs are being conducted and planned to make substantive contributions to solving pressing national, as well as international, problems and needs.

Earth Resources Detection and Monitoring - The effective utilization of the world's finite natural resources requires that their extent and accessibility be surveyed, their changes be monitored and that systems for wisely managing their exploration be developed. In the Earth resources survey area, two objectives have been estalished: (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 the results to oceanography, geology, hydrology, geography, and cartography. Achieving these objectives will provide an information base that can be used in the management of the world's resources.

Significant activities being continued are involved with the Applications Systems Verification Tests program (ASVT) and LANDSAT-C. The Applications Transfer and Demonstration program is designed to demonstrate to the user community that remotely obtained information (from satellites and aircraft) provides new capabilities that may efficiently supplement and/or complement existing data gathering systems. The most significant demonstration taking place 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, the third Earth Resources Technology Satellite, is currently under development, will provide greater resolution and additional information as well as provide continuity after LANDSATS 1 and 2 cease to operate. 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 the Multispectral Scanner (MSS) will incorporate a thermal sensing capability (Fifth Band), providing better discrimination of both land and water features. Development of the Thematic Mapper, a second generation MSS having greater resolution and performance that the current LANDSAT MSS, will eventually provide significantly improved data to the users.

Earth Dynamics Monitoring and Forecasting - 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 instruments will permit a better understanding of this dynamic process and may lead to an earthquake prediction capability. Continuing efforts will be focused on validation of the various plate motion measurement techniques. The third Applications Explorer Mission, Magnetic Field Satellite (MAGSAT), will provide information that will allow the United States Geological Survey to update maps of the earth's magnetic field declination and to develop maps of the global magnetic field as well as enhance our knowledge of the geologic structure of the earth. Studies based on MAGSAT data are expected to provide useful information for location of natural resources such as coal, oil, and minerals.

Ocean Condition Monitoring and Forecasting - This program provides a focus for the use of space platforms and related research efforts to acquire data on the dynamic qualities of the 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, and the possible effects of large bodies of water or climate. 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.

Environmental Quality Monitoring - 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 patterns with respect to time and place; and (3) incorporating the data describing atmospheric constituents and their behavior into atmospheric circulation related environmental quality models. Significant data will be obtained by the second Applications Explorer Mission - Stratospheric Aerosol and Gas Experiment (SAGE) -- which will fly a single instrument to detect and map stratospheric aerosols and gas concentrations. The information derived will complement the data to be obtained by the NIMBUS-G program which is also currently under development.

Weather and Climate Observation and Forecasting - 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 and daily weather and climate, require different approaches and satellite systems to provide data to achieve better forecasts. The major activities will include: (1) continued emphasis on research and technology; (2) severe storm research; (3) the prototype development of 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; and (5) definition and development of experiments and payloads to be flown on early Shuttle/Spacelab missions.

Materials Processing in Space - 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. Effort will continue using small rockets to obtain weightless conditions for short periods to develop experiments that will be flown on the Shuttle/Spacelab. Early definition and design study efforts will also be conducted toward developing the hardware to conduct these experiments on the Spacelab missions.

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, 6) and the cooperative U.S./Canadian Satellite (CAS-C) will continue to be used by various domestic and international experimenters. With the successful completion of the Indian Government's Instructional Television Experiments, ATS-6 will return to the U.S. in the fall of CY 1976 for further experimentation by domestic users. A significant effort will be undertaken to provide technical consultation and support to U.S. Agencies, including NASA, participating in the 1979 World Administrative Radio Conference (WARC), the first of its kind since 1959. NASA involvement is important to assure availability in the frequency assignments for all types of satellites.

Information Management - Information 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 Explorer Missions - Frequently we come upon very valuable concepts for gathering information needed to support the Applications programs. This information often can be obtained by flying a very small, relatively low cost satellite of standard configuration using our lowest cost launch vehicle. The Applications Explorer Mission (AEM) program was established to develop low cost, Scout-launched spacecraft tailored to specific areas of research and orbital requirements. This program has, or will have the following missions underway: (1) the Heat Capacity Mapping Mission (AEM-A) which will obtain temperature data on identifiable characteristics of various materials to develop heat capacity maps of rock types for applications to mineral-potential assessments and for studies of soil moisture, mapping of thermal effluents, measurement of plant canopy temperature, and for the mapping of snow coverage; (2) the Stratopsheric Aerosol and Gas Experiment (AEM-B), which will help develop measurement techniques for the detection and mapping of stratospheric aerosols and ozone by observing the attenuation of the solar radiation through the Earth's atmosphere; and

(3) the Magnetic Field Satellite (MAGSAT), AEM-C, which will map the magnitude and direction of the earth's global magnetic field with improved accuracy. MAGSAT data are needed to refine magnetic field models and charts, to update current magnetic field data for applicable exploration of natural resources and enhances the knowledge of the geologic structures of the Earth.

BASIS OF FUND REQUIREMENTS:

EARTH RESOURCES DETECTION AND MONITORING

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
LANDSAT-1 and -2 (Earth Resources Technology Satellite)	8,700	5,300	5,300	---	---	---
LANDSAT-C (Earth Resources Technology Satellite)	9,000	13,000	13,000	3,500	3,500	13,500
Thematic mapper	---	---	---	---	---	4,000
Applications transfer and demonstration program	8,778	9,300	9,300	2,900	2,500	14,800
Applications research and technology development	32,209	30,130	32,130	7,600	7,200	32,500
Follow-on data analysis and operations	---	---	---	---	700	2,500
Total	58,687	57,730	59,730	14,000	13,900	67,300

OBJECTIVES AND STATUS:

In the Earth Resources Detection and Monitoring program, the principal goals are directed toward providing space derived data toward improving the management of our agricultural, land, water, mineral and marine resources. One important objective in this program is to provide for better management of crop, range, and forestry resources through more timely and accurate production estimates. In the land use areas, the principal goal is to produce land cover maps and computerized information systems that would provide better information for management of our nation's land resources. The development of remote sensing technology for improved water resources management is another important goal of this discipline, as is the location of mineral and petroleum resources by identifying surface appearance of geological conditions and relating them to subsurface conditions. In marine resources, the goal is to monitor and analyze activities in coastal regions for better coastal zone management and to provide information relative to ocean living resources.

To achieve these goals, the objectives are to (1) develop the capability for remote sensing of the earth from spacecraft and aircraft; (2) develop economical methods of extracting useful information from remotely sensed data; and (3) develop experimental and, subsequently, operational applications in concert by the users.

The accomplishments of the Earth Resources Detection and Monitoring program to date includes the successful operation of the first experimental earth resources survey satellite, LANDSAT-1, for over three years in orbit; the operation of the Earth Resources Experiment Package on Skylab and the successful launch operation of the second experimental earth resources survey satellite, LANDSAT-2. Cooperation has been established with user groups at the Federal and state levels, as well as, the private sector in utilizing data for soil mapping application in mining and reclamantion, water quality studies, and watershed monitoring and geological mapping.

The third LANDSAT, scheduled to be launched in late 1977, will carry a fifth band on the multispectral scanner that will provide for the first time,"thermal" or heat sensing data and a special television camera system (Return Beam Vidicon) with 40 meters resolution (as opposed to the 80 meters resolution now available). These data are important to the experimentation and verification testing necessary to determine more precisely the applications and benefits achievable with spaceborne,remote sensing systems. The Thematic Mapper, an advanced multispectral scanner, is being designed to improve spatial resolution and provide more optimized spectral bands for various vegetation applications, including crop inventory, forest surveys, rangeland management, and land use change detection. Additional data of value for investigations in earth resources will be obtained by the Heat Capacity Mapping Mission, the first of the Applications Explorer Missions (AEM-A). This spacecraft will be placed in a unique orbit to obtain thermal data to be used for discriminating rock types, and determining soil moisture conditions. It will also provide frequent coverage of snow fields for water runoff prediction.

In the Applications Transfer and Demonstration program, the most promising areas of remote sensing research are selected and, in concert with user organizations and resource managers, projects are defined that will demonstrate and document the usefulness of remote sensing data to specific resource problems. Examples are the Large Area Crop Inventory Experiment, designed to improve worldwide wheat production forecasts; the Natural Resources Inventory System, an effort to apply computer and space techniques to providing land cover information on a state-wide basis; the Louisiana Environmental Information System, a project to periodically update environmental information with remote sensing data; Icewarn, to monitor ice on the Great Lakes with aircraft borne microwave sensors to aid in extending the winter navigation season; and the Snow Mapping project, to remotely sense changing snow cover conditions and relate the conditions to water runoff in the western part of the United States. In addition to these projects, three or four new ones will be initiated in FY 1977 such as a Water Resources Management Control, Land Management and Vegetation Inventory, and Eastern Surface Mining Monitoring project.

The Applications Research and Technology Development effort includes the system analysis requirement to assess future ASVT possibilities to assure that they are soundly conceived; the design of data handling and processing techniques and equipment, the development of improved (in speed and accuracy) machine-aided interpretation and classification techniques; and the development of improved remote sensors.

Follow-On Data Analysis and Operations provide for continuing the operation of the LANDSAT control center in order to continue the flow of LANDSAT data to the user community and to provide in-house monitoring and other administrative support for the LANDSAT principal investigator program.

LANDSAT-C (Earth Resources Technology Satellite)

	1975	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
			(Thousands of Dollars)			
Spacecraft	4,000	9,000	9,225	3,200	2,300	8,430
Sensors	5,000	3,500	3,100	200	950	2,670
Ground operations	---	500	675	100	250	2,400
Total	9,000	13,000	13,000	3,500	3,500	13,500
Delta (Expendable launch vehicles program)	(---)	(3,000)	(1,400)	(---)	(800)	(3,000)

OBJECTIVES AND STATUS:

The objective of the LANDSAT-C Earth Resources Technology Satellite project is to continue the development of technology which will significantly contribute to more efficient management of earth resources. It accomplishes this objective by providing large area repetitive images in discrete color bands, which can be analyzed by computer and photointerpretation techniques to provide a better understanding of terrestrial conditions than is presently possible. LANDSAT-C will continue and build on the technology developed by LANDSAT-1 and -2. LANDSAT-C will carry an improved Multispectral Scanner (MSS), which will incorporate a new spectral band in the thermal region to more effectively classify terrestrial phenomena which are characterized by temperature changes. This additional capability will be used to improve our ability to classify and measure agricultural crops in the preharvest stage and will also improve LANDSAT's capability to monitor dynamic changes in many other vital areas such as water pollution, geology, hydrology, and oceanography. The television camera system, called the Return Beam Vidicon, will incorporate a twofold improvement in resolution (80 to 40 meters) over what was flown on LANDSAT-1 and -2. This capability will permit the identification of smaller agricultural fields and should assist in improving cartography in poorly mapped areas of the world.

LANDSAT-C development efforts are well underway, leading to launch in 1977. During FY 1976 and the Transition Quarter, the LANDSAT-C spacecraft fabrication and assembly will continue. The Multispectral Scanner will be completed, tested, and shipped to the prime contractor for integration into the spacecraft. The higher resolution Return Beam Vidicon system will be going through its assembly and final test phases in preparation for its delivery in January 1977.

CHANGES FROM BUDGET ESTIMATES:

The current FY 1976 and Transition Quarter estimates for LANDSAT-C development remain the same, in total, as the budget estimates. Adjustments within project elements in FY 1976 and the Transition Quarter were due largely to the rephasing of FY 1976 requirements for the development of the five-channel Multispectral Scanner. Delays in subsystem deliveries for this instrument resulted in the deferral of funding previously planned in FY 1976 to the Transition Quarter. The resulting rephasing of the spacecraft funding has been negotiated with the prime contractor.

BASIS OF FY 1977 ESTIMATES:

FY 1977 funds will be utilized to complete the assembly of the spacecraft and the integration of the payload. The integrated spacecraft with payload will undergo a series of rigid verification tests to assure its proper orbital performance. The changes required for the ground system to provide for compatibility with the improved sensors will be completed, checkout out, and their operational readiness verified. LANDSAT-C is currently scheduled to be launched from the Western Test Range in 1977.

Thematic Mapper

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Sensor development	---	---	---	---	---	4,000

OBJECTIVES AND STATUS:

The objective is to develop a second generation multispectral scanner, or Thematic Mapper, to provide improved spatial resolution and optimized spectral coverage for land cover applications. These include crop inventory, water management, and land use change detection.

Our experience to date with data from LANDSAT-1 and 2 has dramatically proved that the multispectral analysis technique -- identifying surface features by comparing the radiation reflectance emitted by the

Earth's surface in discrete color bands -- to be very effective for a large number of applications. While the results to date have proven that significant benefits can be realized using the Multispectral Scanner, studies have shown that improvements to the scanner would permit a sizable increase in the anticipated economic return. An increase in resolution will significantly increase possible applications. In addition, studies show that improvement of other instrument features (increased precision in the radiance measurements and the number and size of the color bands) will be equally significant in improving analytical ability. The result will be increased use of multispectral analysis in crop production forecasting, forestry inventory, land use monitoring, wet land surveys, geological interpretation, and agriculture inventories. In crop production forecasts, the Large Area Crop Inventory Experiment (LACIE) is proving our ability to monitor wheat production on a world-wide basis. While wheat is the primary food product in world trade, a knowledge of wheat production alone is not sufficient to determine the inventory of the world's limited food supplies. The improved spectral and spatial resolution of the Thematic Mapper will increase the benefits realized from monitoring wheat production and also facilitate the extension of the techniques developed in the LACIE program to other crops and to crops grown in smaller fields.

The improvements needed to increase the information content and obtain these benefits are as follows: the resolution of the Thematic Mapper will be 30 meters compared to the present 80m available in the LANDSAT-C Multispectral Scanner (MSS), seven optimized spectral bands will be available in the Thematic Mapper compared to five broader bands on the LANDSAT-C MSS, and the precision of the measurement of the radiation intensity in the Thematic Mapper will be a factor of four better than in the LANDSAT-C MSS.

BASIS OF FY 1977 ESTIMATE:

The feasibility of developing a seven-band scanner with increased resolution has been demonstrated by preliminary design studies. Critical design areas have been identified and are being investigated through breadboard studies to be completed in early 1976. Proposals will be solicited in 1976 so that the design phase can be completed in 1977. The FY 1977 funds will be utilized to complete the design and to procure the necessary long-lead items and initiate fabrication and assembly of the Thematic Mapper.

Applications Transfer and Demonstration Program

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Applications transfer and demonstration program	8,778	9,300	9,300	2,900	2,500	14,800

OBJECTIVES AND STATUS:

The Applications Transfer and Demonstration program includes major projects conducted under agreements with other Federal agencies, state, and regional Governments, (referred to as Applications System Verification Tests (ASVT)) and the regional applications transfer projects.

The objective of the ASVT program is to take the most promising application areas and -- through a concerted effort with user organizations and resources managers -- define, demonstrate, and transfer the practical capability of remote-sensing-based information systems to make substantial contributions in these areas. In contrast, Regional Applications Transfer projects are smaller in scale and involve direct cooperation between NASA Center personnel and local user organizations.

One of our present ASVT's will be completed in FY 1976; this is the Icewarn project conducted jointly by the U.S. Coast Guard, NOAA and NASA to monitor ice movements on the Great Lakes. The U.S. Coast Guard has plans to assume the operational responsibility for providing these services.

CHANGES FROM BUDGET ESTIMATES:

This decrease of $400 thousand in the Transition Quarter reflects adjustments resulting from the general congressional reduction in NASA's R&D budget request for this three month period. This necessitated the deferral of the start of some application transfer tasks until FY 1977, which will slow the progress of transferring to the users the capability of applying remotely sensed resources information systems.

BASIS OF FY 1977 ESTIMATES:

The ASVT's initiated in prior years and continuing through FY 1977 include the following: (1) the Large Area Crop Inventory Experiment (LACIE), which is a joint investigation by the U.S. Department of Agriculture, the National Oceanic and Atmospheric Administration (NOAA) and NASA to develop and test the use of data gathered by spacecraft and analyzed with the aid of computers to improve the objectivity, timeliness, and accuracy of worldwide crop production forecasts; (2) the National Resources Inventory System, a joint investigation by the State of Mississippi and NASA to test an automated natural resources inventory system based on remotely sensed data oriented to state or regional use and directed at specific applications; (3) the Louisiana Environmental Information System, a joint investigation with the Corps of Engineers to test an automated environmental information system based on remotely sensed data for the updating of basic environmental data in a predominantly wetlands area; and (4) the western states Snow Mapping ASVT, the purpose of which is to remotely sense changing snow conditions and relate it to water runoff in the western part of the United States is being sponsored by six Federal and three state agencies.

Several projects are in the planning stage and are expected to lead to ASVT's in FY 1977. Those that appear most promising include: (1) the possible development of Land Management and Vegetation Inventory ASVT as the result of an expressed desire of the Bureau of Land Management (BLM) to conduct a joint program

with NASA which would involve the use of remote sensing to inventory and monitor rangeland vegetation; (2) a Water Resources Management and Control project which is being planned with the Corps of Engineers and the State of California to test the utility of LANDSAT data in water supply and demand situations that require the use of hydrological land use classifications; and (3) an Eastern Surface Mine Monitoring ASVT which is under discussion with the Appalachian Regional Commission and its member states.

Applications Research and Technology Development (Earth Resources)

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Data interpretation techniques, special investigations and data analyses	17,415	19,600	21,600	5,000	5,200	22,300
Development of advanced flight experiments for earth resources detection and monitoring	600	600	600	200	200	600
Aircraft support for development of capabilities in remote sensing of earth resources	7,700	5,700	5,700	1,200	1,000	6,000
Studies in applications of earth resources detection and monitoring technology	1,612	1,600	1,600	300	200	1,500
Development of Spacelab payloads for earth resources applications	1,700	1,100	1,100	900	600	2,100
Other studies and support	3,182	1,530	1,530	---	---	---
Total	32,209	30,130	32,130	7,600	7,200	32,500

OBJECTIVES AND STATUS:

The objectives of this effort are to improve data handling techniques, data processing equipment, and machine-aided interpretation and classification techniques needed to increase efficiency in the transformation of space derived data into information for utilization by the user community. An additional objective is to develop new remote sensors operating primarily in the microwave wavelengths. The microwave sensors, are of particular interest since they permit the collection of earth surface images through cloud cover. This program includes the aircraft support for the development of remote sensors, sensing techniques and collecting of "ground truth" data; Space Shuttle flight studies including sensor development, and measurement-technique verification; and development, through the proof of concept phase, of advanced flight experiments associated with remote sensing of earth resources. Examples are an Active (Laser)-Passive Multispectral scanner, and an advanced data analysis system.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate: The increase of $2.0 million for Data Interpretation Techniques, Special Investigations and data analysis provides for additional tasks associated with the definition of future earth resources missions.

Transition Quarter Estimate: The net decrease of $400 thousand reflects adjustments resulting from the general congressional reduction in NASA's R&D budget request for this three-month period.

BASIS OF FY 1977 ESTIMATES:

In FY 1977, emphasis will be placed on developing new projects to demonstrate repetitive, operational applications of remotely sensed data (examples are monitoring sea ice and forestry management), to develop and document advanced techniques for the extraction of remotely sensed data (such as understanding the relative contributions of soil moisture, meteorological conditions and vegetation in the analysis of thermal infrared data), and to develop new remote sensing instruments with emphasis on active and passive microwave sensors because of their all-weather and day/night observation capability. In all these areas, priority will be given to vegetation monitoring because of the breadth of applications associated with it and the anticipated economic benefits.

Aircraft support for the Earth Resources Survey program in FY 1977 will focus on the definition of active and passive microwave sensors for soil moisture and vegetation studies, snow characteristics and watershed runoff measurements. The use of airborne platforms in evolving the potential of microwave remote sensing applications is oriented primarily toward the development of sensors for Space Shuttle and other satellite payloads. Airborne support will also be provided for Application Transfer and Demonstration programs.

In FY 1977, the development of Advanced Applications experiments will be carried further towards proof of concept for hardware to fly on the Shuttle. This will include in the microwave field-radar and in the optical field-laser radar, which are both very promising areas for future applications.

Follow-On Data Analysis and Operations (Earth Resources)

	1975	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)				
LANDSAT-1 and -2 extented operations.....	---	---	---	---	700	2,500

OBJECTIVES AND STATUS:

We are very fortunate to be able to continue receiving high quality data from both the LANDSAT spacecraft now in orbit, even though both have exceeded their design life of one year. This situation permits the acquisition of data every nine days over the United States which is extremely important to observe and map short term, fast changing phenomena such as snow cover and flooding. The increased frequency of coverage also improves the probability of gathering imagery from areas which are frequently cloud covered. In addition, the extended lifetime permits supporting the entire LANDSAT user community with data to develop applications such as the monitoring of land use and the classification and measuring of crop acreage. The total 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 objectives of the Follow-on Data Analysis and Operations are, therefore, to continue the acquisition of frequent and repetitive large scale images of the earth from LANDSAT spacecraft now in orbit.

CHANGES FROM BUDGET ESTIMATES:

This is a new budget line item beginning in the Transition Quarter to provide for flight operations and investigator support to take advantage of the extended lifetimes of LANDSAT-1 and -2 spacecraft.

BASIS OF FY 1977 ESTIMATE:

FY 1977 funds are required to continue operating the control center for the LANDSAT satellites. Funding also includes the in-house support required by GSFC to manage the Principal Investigator program. This funding provides the support necessary to ensure that data are utilized efficiently and that resulting reports are timely and adquate.

BASIS OF FUND REQUIREMENTS:

EARTH DYNAMICS MONITORING AND FORECASTING

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)					
Geodynamic experimental ocean satellite (GEOS-3)	500	---	---	---	---	---
Laser geodynamic satellite (LAGEOS)	1,300	1,000	1,000	300	300	---
Tectonic plate motion	1,900	2,600	2,600	800	700	1,900
Applications research and technology development (ARTD)	4,800	3,300	3,300	900	900	1,300
Follow-on data analysis and operations	1,100	1,100	1,100	400	300	1,400
Total	9,600	8,000	8,000	2,400	2,200	4,600

OBJECTIVES AND STATUS:

The Earth Dynamics Monitoring and Forecasting program is a cohesive merging of the analytical and experimental techniques of the geophysical disciplines with global space measurement capabilities. The objectives of the program are to develop and demonstrate the application of techniques for detection of crustal motion, for gravity and magnetic field mapping, for evaluation of polar motion and earth rotation variations, and for earthquake-related study.

The development of these capabilities is expected to lead to improvements in geodetic mapping, improved magnetic field models and charts, identification of potential areas for resource exploration (coal, oil, minerals, etc.), and precursor monitoring systems for geological hazard assessment.

This program is being carried out through a broad-based effort involving the analytical and experimental development of measuring techniques and instruments, the development of ground and space systems, and the acquisition and analysis of data acquired through ground and satellite measurements.

The GEOS-3 mission, launched in April 1975, is providing nearly global altimeter data on the mean level of the ocean surface or ocean geoid. These data and other tracking data are used to refine models of the earth's gravity field and to infer subterranean ocean features.

The Laser Geodynamic Satellite (LAGEOS) project will provide a nearly permanent reference point in space for earth dynamics studies. LAGEOS, a very dense (high mass to volume ratio) satellite, will permit very

accurate laser ranging measurements and will be the first satellite compatible with the precision earth motion measurements required for crustal motion and earthquake studies. The launch of LAGEOS is planned for early 1976.

A related Spacecraft Development project, which is separately budgeted under the Applications Explorer Missions (AEM) category, is the Magnetic Field Satellite (MAGSAT), planned for initiation in FY 1977. This mission will provide accurate magnetic field mapping of the earth. This information is required by the U.S. Geological Survey (DOI) to update maps and charts used in navigation and will provide important new data for scientific studies, global field model development, and investigations of the potential for resource explorations.

The Tectonic Plate Motion project includes several joint experiment efforts involving the U.S. Geological Survey and the National Geodetic Survey (DOC). These include the use of laser tracking of satellites to determine surface motions along an active fault (San Andreas Fault Experiment) and the use of Very Long Baseline Interferometry. In FY 1977, it is planned to initiate an intercomparison and validation of techniques to evaluate system effectiveness.

FY 1977 funding also provides for the continuation of on-going activities in Applications Research and Technology Development, and for the continued support of investigations using data acquired from space missions and ground observation, and the extension of observations using missions which have exceeded expected durations.

Tectonic Plate Motion

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Tectonic plate motion.....	1,900	2,600	2,600	800	700	1,900

OBJECTIVES AND STATUS:

The objective of the Tectonic Plate Motion project is to develop techniques for the detection and forecasting of the relative motion of the large plates which form the earth's crust. The plates are believed to be in motion with respect to each other by amounts ranging from a few to 15cm per year. The movement of tectonic plates is believed to be one of the keys to understanding earthquake mechanisms. It is also believed that the plate motion mechanism is associated with mineralization.

In past years this project has supported experiments related to accurate measurements of long baselines (greater than 100 km), the detection of plate motion and fault motion, and to the validation of the techniques

to make the precision measurements required. The measurement of extended distances (coast-to-coast) to a repeatability of about 20 centimeters has been demonstrated using laser ranging and Very Long Baseline Interferometer (VLBI) techniques. These experiments include: (1) A joint effort coordinated with the U.S. Geological Survey (DOI) to demonstrate the feasibility of using satellite tracking lasers to determine surface motions along an active fault (San Andreas Fault Experiment - SAFE); (2) A regional effort in California, supported by the National Geodetic Survey (DOC) ground based surveys and validation, to demonstrate the use of Very Long Baseline Interferometry (VLBI) techniques for the measurement of regional crustal motion, using distance stars as a reference (Astronomical Radio Interferometric Earth Surveying - ARIES); and (3) A multi-faceted effort to determine the relative motions of the Pacific plate and the North American plate using Very Long Baseline Interferometer techniques (Pacific Plate Motion Experiment - PPME).

CHANGES FROM BUDGET ESTIMATES:

The decrease of $100 thousand in the Transition Quarter reflects adjustments resulting from the general congressional reduction in NASA's R&D budget request for this three-month period, and will require an adjustment in the planned rate of data collection.

BASIS OF FY 1977 ESTIMATES:

FY 1977 funds will provide for continuation of crustal motion experiments, with emphasis on inter-comparison of the laser ranging and Very Long Baseline Interferometer techniques. This inter-comparison will assist in identifying and reducing systematic errors in each technique and provide estimates of the absolute errors.

APPLICATIONS RESEARCH AND TECHNOLOGY DEVELOPMENT (Earth Dynamics)

	1975	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
			(Thousands of Dollars)			
Measurement systems, forecasting techniques and modeling/advanced studies	2,900	2,200	2,200	600	600	1,300
Advanced earth dynamics flight experiments	900	300	300	100	100	---
Flight support for earth dynamics	500	300	300	100	100	---
Earth dynamics systems analyses	300	300	300	100	100	---
Spacelab payload definition for earth dynamics experiment	200	200	200	---	---	---
Total	4,800	3,300	3,300	900	900	1,300

OBJECTIVES AND STATUS:

The objective of the ARTD activities for the Earth Dynamic Monitoring and Forecasting program is to support the analytical and experimental effort leading to the development of techniques and instruments for studies of earth dynamics phenomena such as variation of the gravity field and magnetic field, crustal motions, polar motion, and variations in the earth's rotation rate. These activities include the development and verification of models of the dynamic earth; the definition of measuring techniques and systems capable of the required accuracies; sensor design studies for satellite and Spacelab missions; and demonstration of the applications of these capabilities to user requirements.

In FY 1976, modeling of the earth's gravity field has been extended and refined and a new model of the earth's magnetic field was developed using previous satellite data. Work was continued on studies of crustal motions, on conceptualization of convection cells within the earth's mantle, on utilization of satellite derived gravity and magnetic field models for resource assessment, on the motions of the earth's polar axis, and on the analysis of earthquake data. Concepts for improved laser ranging techniques and instruments were studied.

BASIS OF FY 1977 ESTIMATES:

FY 1977 funds will provide for continuation of ARTD activities for the Earth Dynamics Monitoring and Forecasting program. Efforts will be generally focused on improvements in the definition of the earth's gravity and magnetic field models using existing data. Though the improvements in the models are required for today's activities, they are also required to support the Ocean Dynamics Satellite -- SEASAT-A -- and the Magnetic Field Satellite, an Applications Explorer.

Follow-On Date Analysis and Operations (Earth Dynamics)

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Follow-on data analysis and operations.....	1,100	1,100	1,100	400	300	1,400

OBJECTIVES AND STATUS:

The objective of this project is to analyze the application of laser and microwave data, other satellite tracking data, and ground measurements for application to studies of gravity field modeling, to detection of fault motion, and to determination of geodetic control points. Included in these studies are the analysis and evaluation of new methods of making precision measurements as well as intercomparisons of empirical and analytical techniques.

CHANGES FROM FY 1976 BUDGET ESTIMATES:

The decrease of $100 thousand in the Transition Quarter reflects adjustments resulting from the general congressional reduction in NASA's R&D budget request for this three-month period, and will necessitate a decrease in the analysis of satellite data.

BASIS OF FY 1977 ESTIMATES:

FY 1977 funds will provide for continuation of the effort on the data acquired with the GEOS-3 altimeter, the ASTP gravity field experiments, laser ranging to LAGEOS, and conventional satellite tracking. These data will be analyzed to continue refinement of earth gravity field models and other earth dynamics experiments. Analysis of previous satellite-acquired magnetic field data will be continued in support of the planned MAGSAT mission. In addition, data sampling and analysis techniques will be developed for the conversion of satellite data into a format useful to the user community.

BASIS OF FUND REQUIREMENTS:

OCEAN CONDITION MONITORING AND FORECASTING

	1975	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
	(Thousands of Dollars)					
Geodynamic experimental ocean satellite (GEOS-3)	400	---	---	---	---	---
Ocean dynamics satellite (SEASAT-A)	8,000	17,000	15,000	5,000	5,000	25,300
Applications research and technology development (ARTD)	5,600	4,200	4,200	1,400	1,100	3,500
Follow-on data analysis and operations	1,600	1,600	1,600	400	400	1,800
Total	15,600	22,800	20,800	6,800	6,500	30,600

OBJECTIVES AND STATUS:

The Ocean Condition Monitoring and Forecasting program has as its objectives improvements in marine operation such as shipping, off shore construction and operations, and fishing. In addition, the monitoring and forecasting of ocean surface conditions is expected to contribute significantly to the development of long range global weather forecasting. These objectives will be achieved through the development and demonstrated applications of modeling and measurement techniques associated with the determination and monitoring of ocean surface conditions, ocean current systems, ocean circulation patterns, air/sea interface, and sea surface topography.

Monitoring of the ocean surface conditions includes surface roughness, wave height, length and direction; sea surface temperature, and wind speed and direction. This information can be valuable to evaluation of scientific phenomena to scale overall observations of ocean currents, and as input to computer-aided prediction models that produce forecasts.

This program is being carried out through an integrated NASA/User community effort involving the analytical and experimental development of measuring techniques, the development of space systems such as SEASAT and GEOS-3, and the acquisition and analysis of data acquired through airborne, satellite, and ground measurements.

The frequent global coverage provided by satellite measurements creates valuable information for a wide variety of users. An example is the SEASAT-A agreement to provide data to the Navy's Fleet Numerical Weather Center. The data would be less than six hours old, and would be used on a trial basis within their forecasting programs.

FY 1977 funds will provide for the continuation of the development and fabrication of the spacecraft bus and sensors for the Ocean Dynamics Satellite (SEASAT-A) for a 1978 launch, the continuation of the ARTD activities, and the support of a second year of operations and data analysis for GEOS-3, launched in April 1975.

OCEAN DYNAMICS SATELLITE (SEASAT-A)

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Spacecraft and support	---	7,000	9,075	1,700	1,065	15,315
Sensor development	8,000	10,000	5,840	3,300	3,875	8,715
Mission operations	---	---	85	---	60	1,270
Total	8,000	17,000	15,000	5,000	5,000	25,300
Atlas-F (Expendable launch vehicles program)	(---)	(---)	(---)	(---)	(---)	(3,400)

OBJECTIVES AND STATUS:

The objective of the Ocean Dynamics Satellite (SEASAT-A) mission is a demonstration of global monitoring of oceanographic phenomena, including demonstration of the key features of an ocean dynamics monitoring system

to collect data for practical applications and scientific research in ocean forecasting modeling. Based on the results of the SEASAT-A analyses and the improvements they will afford in ocean and weather models, forecasting systems will be developed to more accurately predict ocean conditions as well as provide the ocean influence inputs necessary for extended worldwide weather forecasting.

In 1976, development activities, fabrication and preliminary test of the spacecraft bus will continue. The design and development of the sensors and the sensor module are in process. Effort is continuing on the definition of the physical interface between the spacecraft and sensor instrument actions.

SEASAT-A will weight 1,800kg and will be launched into an orbit having an inclination of 108 degrees and an altitude of 800km. It will utilize a spacecraft bus attached to a sensor module equipped with three active sensors: a radar altimeter; a synthetic aperture imaging radar; and a microwave wind scatterometer. A visible and infrared scanning radiometer, and a scanning multispectral microwave radiometer are passive sensors that complete the sensor module payload. These instruments will provide the capability to monitor the world's oceans every 36 hours and detect sea state (wave height), wind speed, wind and wave direction, along with ocean temperature and ocean surface topography from which ocean currents and geoid parameters can be derived.

CHANGES FROM THE BUDGET ESTIMATES:

The $2 million reduction in the FY 1976 estimate, and adjustments among the project elements in both FY 1976 and the Transition Quarter, reflect a restructuring of the activities assigned to each project element and a delay in the initiation of certain work. The sensor module portion of the sensor development effort, and a larger fraction of the overall systems integration responsibility, are now assigned to the spacecraft prime contractor. These changes in the hardware assignments, contributed to improved project efficiency. These adjustments resulted in minor delays in the initiation of the sensor procurements, however, the launch of SEASAT-A is still planned for 1978.

BASIS OF FY 1977 ESTIMATES:

FY 1977 funds will provide for the completion of the manufacturing and testing of each of the SEASAT-A sensors and the satellite bus. Individual sensor tests and integration of sensors into the sensor module that is attached to the bus will begin in 1977 and will continue through early 1978 in preparation for a mid-1978 launch.

APPLICATIONS RESEARCH AND TECHNOLOGY DEVELOPMENT (OCEAN CONDITIONS)

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Measurement systems, forecasting techniques and modeling/advanced studies	1,200	900	900	300	200	900
Advanced ocean dynamics flight experiments	100	300	300	---	---	---
Ocean surface truth measurements	3,700	2,400	2,400	900	800	1,900
Ocean dynamics systems analyses	600	600	600	200	100	700
Total	5,600	4,200	4,200	1,400	1,100	3,500

OBJECTIVES AND STATUS:

This project supports the analytical and experimental effort associated with theoretical studies of ocean phenomena; the establishment of user requirements for ocean monitoring; the definition of systems capable of making the required measurements and accuracies; the assessment of economic benefits; the development of advanced system and sensor technology; the preliminary design of sensors for satellite and Shuttle missions; and the support of aircraft and ground truth measurements to verify system concepts.

CHANGES FROM BUDGET ESTIMATES:

The decrease of $300 thousand in the Transition Quarter budget estimate reflects adjustments resulting from the general congressional reduction in NASA's budget request for the three-month period, and requires a general reduction in the ocean dynamics aircraft experiment program.

BASIS OF FY 1977 ESTIMATES:

FY 1977 funds will provide for the continuation of the airborne tests. These and the ground and ocean truth efforts will emphasize the validation and calibration of SEASAT-A sensors and data processing programs. In addition, studies supporting the development of advanced ocean dynamics sensors will be initiated.

Follow-on Data Analysis and Operations (Ocean Conditions)

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Follow-on data analysis and operations.....	1,600	1,600	1,600	400	400	1,800

OBJECTIVES AND STATUS:

This project provides for the analysis of the ocean data already acquired with GEOS-3 and other space and ground systems and the support of extended GEOS-3 operations. These analyses provide the basis for the development of techniques and models which relate ocean measurements to specific applications such as: the correlation of active microwave backscatter with the height of ocean waves and the speed and direction of the wind near the surface, the detection of current systems; and the development of models of the ocean's mean sea level, or geoid.

BASIS OF FY 1977 ESTIMATES:

FY 1977 funds will provide for the support of a second year of operations for the GEOS-3 mission, and will allow increased emphasis on numerical modeling of ocean dynamics conditions. Some of the major analyses to be supported in FY 1977 include: the development of models which relate the ocean bottom topography to the ocean surface as defined by satellite altimetry; the refinement of models relating measured microwave parameters to sea state; and the development of an improved ocean geoid to support mapping ocean current systems mapping planned for SEASAT-A.

BASIS OF FUND REQUIREMENTS:

ENVIRONMENTAL QUALITY MONITORING

Air pollution and oceanographic observing satellite (NIMBUS-G).....	19,000	15,000	13,000	7,500	6,700	15,400
Spacelab payload development.....	---	---	---	---	---	800
Applications research and technology development.....	7,400	9,200	9,200	3,100	2,700	9,900
Total.....	26,400	24,200	22,200	10,600	9,400	26,100

OBJECTIVES AND STATUS:

The primary objectives of the Environmental Quality Monitoring program are: (1) to develop remote sensors to detect pollution; (2) to develop analytic techniques and models to interpret sensor data and predict the state of the environment; and (3) to evaluate and apply remote sensors to environmental monitoring through inter-agency efforts.

Pollution of the earth's air and water environment occurs on local to global scales. Indications are that long range effects of regional and global pollution may be severe and the need for information to better understand the physical and chemical processes involved is of great urgency. The environment must be monitored to determine its present state and changes, to understand the effects of man's activities, and to provide the data needed to evaluate the effectiveness of control strategies and the validity of regulatory policies.

From the point of view of global pollution, the atmospheric layer of primary concern at the present time is the stratosphere. The technology now exists or is being developed to detect many of the natural and manmade pollutants that enter the stratosphere either directly, e.g., from volcanoes or supersonic transport operations, or indirectly by diffusion from the lower atmosphere, e.g., from organic processes or industrial activities. However, in order to extend this technology into a monitoring system which can be used to study the effects of manmade pollution, it will be necessary to develop a set of global baseline data on stratospheric composition. Aircraft flights and sounding rockets are providing limited data on the distribution and variability of stratospheric temperature and winds and of its constituents such as aerosols, ozone, and nitric oxide. Advanced instrumentation will be developed to permit measurements of other constituents of environmental importance including nitrogen dioxide, nitric acid, atomic oxygen, and chlorine oxide. The NIMBUS-G satellite and the AEM-B/Stratospheric Aerosol and Gas experiment (SAGE) will provide global coverage of aerosols and a number of important gaseous constituents including ozone. Second-generation instruments, e.g., laser and microwave sensors, are also being planned to provide the capability for measurement of these and additional important atmospheric constituents with much greater resolution. Models, now being developed, are needed to help with data analysis and to provide forecasts of pollutant dispersion and its impact.

Most pollution of the lower atmosphere (troposphere) is of localized origin. Ambient air standards and emission control regulations have been promulgated to protect the health and welfare of the nation, but it is recognized that better supporting information is necessary to assure their validity. Also, the ability of many locales to meet ambient air standards can be seriously impacted by pollutants transported from the adjacent regions. Remote sensors now being developed will supplement current in situ sensors both in locating pollution sources and in providing needed rapid synoptic coverage. Tropospheric sensor development effort was intensified in FY 1976 and will continue to be emphasized in the coming year. Initial evaluations of passive tropospheric pollution remote sensors are being conducted using aircraft. A remote monitoring capability for carbon monoxide, ozone, ammonia, methane, and sulfur dioxide will be

demonstrated. Testing of both passive and active sensors will be directed toward a possible joint program with user agencies in FY 1978 to demonstrate the utility of airborne remote sensors in meeting current monitoring needs. Analytic techniques to interpret measurements and predict pollution dispersion are also being developed. In the coming year boundary layer effects will be included in numeric models and improved chemistry will be added to self-consistent dispersion/meteorological models.

Water color variation due to substances in suspension is the physical phenomenon that makes possible the detection, discrimination, and quantification of water pollutants and other water quality parameters. Space imagery, provided by LANDSAT in particular, has shown color variations which have been attributed to such factors as acid wastes and sewage sludge dumps, industrial effluents, heavily sedimented rivers, and algal blooms. Research has led to the definition of spectral regions and data analysis algorithms which allow a quantitative inference of sediment, chlorophyll, and salinity, and resulted in the development of an instrument (Coastal Zone Color Scanner) which is to be flown on NIMBUS-G. The optical properties of water pollutants remains a basic and continuing research objective needed for establishing sensor design requirements and data interpretation techniques. In addition to the increased emphasis in spectral and analytical techniques, the areas of application focus will include ocean dumping, red tide research, and classification of the eutrophic status of lakes. These tasks will be conducted cooperatively with other Federal agency and state participation.

AIR POLLUTION AND OCEANOGRAPHIC OBSERVING SATELLITE (NIMBUS-G)

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Spacecraft	5,917	5,500	6,075	2,500	3,000	5,300
Sensors and data analysis	13,083	7,900	6,705	4,100	2,650	7,100
Ground support	---	1,600	220	900	1,050	3,000
Total	19,000	15,000	13,000	7,500	6,700	15,400
Delta (Expendable launch vehicles program)	(---)	(---)	(---)	(---)	(---)	(2,500)

OBJECTIVES AND STATUS:

The objectives of the NIMBUS-G mission are: (1) to establish baseline measurements of atmospheric gaseous and particulate content and to assess general global trends, movements, and interactions, as pollutants are further released by man and nature; (2) to map sediments and coastal effluents in order to better control

them and their effects; (3) to improve ship routing through the observation of polar and floe characteristics; (4) to enhance the capability for long-term weather prediction; (5) to support the Global Atmospheric Research program by measuring sea-surface temperature, precipitation, snow and ice cover, and soil moisture; and (6) to continue taking measurements, begun on NIMBUS-4, which will be used to establish the long-term trend of the earth's radiation budget and protective ozone layers.

In order to meet these objectives, the NIMBUS-G spacecraft payload consists of four sensors for measurement of atmospheric gaseous and particulate pollutants, two sensors for measurement of oceanographic parameters such as coastal patterns, and two sensors for continuation of baseline measurements of the earth's radiation budget.

During FY 1976 and the Transition Quarter, the instrument and spacecraft designs will be completed. The first design proof instrument models will be fabricated, and testing will be underway to verify their ability to meet operational and critical environmental requirements. These same units will then be integrated into a simulated spacecraft test fixture for compatibility testing of interfaces.

CHANGES FROM THE BUDGET ESTIMATES:

Funding adjustments in this project result in net decreases of $2 million in the FY 1976 estimate and $800 thousand in the Transition Quarter estimate. Within these net decreases, the changes among project elements stem from a technical change to the spacecraft and rephasing of certain project activity.

Increased spacecraft funding is the result of the decision to incorporate the Unified S-Band capability in order to accommodate the planned phaseout of VHF equipment at the Spaceflight Tracking and Data Network (STDN). In addition, delays in material procurement, a slower than planned buildup of sensor contractor manpower, and rephasing in the definition and design of ground systems required adjustments in these areas.

BASIS OF FY 1977 ESTIMATES:

FY 1977 funds will provide for the continued fabrication and environmental testing of both the flight instrument models and the NIMBUS-G spacecraft, in order to prepare them for final integration and checkout in preparation for a late CY 1978 launch. The requirements also include funds for the science support teams which will optimize the type and format of the experiment data products necessary for the post-launch scientific investigations. Along with this activity, augmentation of existing ground station equipment and computer programs to support the mission will continue.

Spacelab Payload Development (Environmental Quality)

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Sensor development.....	---	---	---	---	---	800

OBJECTIVES AND STATUS:

The Shuttle/Spacelab offers a valuable opportunity to operate large survey type instruments in orbit which are capable of making detailed measurements over a wide range of the spectrum. Data from this kind of experiment would be used in developing smaller dedicated instruments for use in measurements of specific atmospheric constituents in much narrower spectral regions. Of particular concern are those gaseous pollutants introduced by man into the atmosphere which, through chemical reactions, could possibly modify the earth's stratospheric ozone layer. This work is aimed at developing one such sensor, an advanced version of the High Speed Interferometer (HSI) which will have capability to make global measurements of lower atmospheric (tropospheric) and upper atmospheric (stratospheric) trace gases which have absorption bands in the infrared spectral range. This sensor will make it possible to develop a baseline of existing stratospheric constituents and their concentrations. These include such gases as hydrogen chloride, water, ammonia, methane, nitrous oxide, deuterium oxide and ozone. These data are needed if a long term stratospheric monitoring system is to be developed, both to provide an identification of the species of interest and to provide the parameters needed for the design of other, more specific, monitoring instruments. Early versions of the instrument have flown on aircraft and balloons and have provided such valuable data as the first stratospheric measurement of hydrogen chloride (HCl), an important gas species in the chemistry of ozone depletion

BASIS OF FY 1977 ESTIMATES:

FY 1977 funds will provide for initiation of the design and development of the advanced version of the High Speed Interferometer. Earlier versions of the sensor have established the nature of most of the problem areas. Application of this information will greatly simplify the task of designing and fabricating this sensor for Spacelab applications. In FY 1977, instrument design studies will be completed and fabrication of the instruments will be initiated.

APPLICATIONS RESEARCH AND TECHNOLOGY DEVELOPMENT (ENVIRONMENTAL QUALITY)

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Sensor definition and feasibility evaluation modeling	3,400	4,200	4,200	1,200	1,100	4,200
Development of advanced flight experiments for environmental quality monitoring	1,400	1,300	1,300	600	600	1,300
Aircraft support for development of capabilities in remote sensing of environmental quality	700	2,600	2,600	700	700	2,600
Studies in applications of environmental quality monitoring technology	700	600	600	200	100	700
Definition of Spacelab payloads for environmental quality monitoring applications	1,200	500	500	400	200	1,100
Total	7,400	9,200	9,200	3,100	2,700	9,900

OBJECTIVES AND STATUS:

This activity is directed toward the development and demonstration of remote sensing technology and the analytic tools to interpret sensor measurements and assess the impact of pollution for atmospheric and water pollution monitoring applications. The basic techniques and instruments are developed as part of the sensor definition and advanced flight experiments activities. Each area is also supported by the airborne operations.

CHANGES FROM BUDGET ESTIMATES:

The decrease of $400 thousand in the Transition Quarter budget estimate results from the general congressional reduction in NASA's R&D budget request for this three-month period. This reduction will require adjustments in the schedules for defining and evaluating pollution monitoring sensors for measurements of the stratosphere, and the definition of environmental quality payloads for the Spacelab.

BASIS FOR FY 1977 BUDGET ESTIMATES:

In FY 1977, stratospheric applications will focus on the needs for monitoring the nitrogen-ozone and halogen-ozone chemical cycles. This work will be further supported by special sounding rocket launches

as well as those from the standard meteorological rocket network. Studies will continue on post-NIMBUS-G pollution monitoring tasks using Spacelab. Second-generation multigas sensors, especially the Laser Heterodyne Spectrometer and the Measurement of Air Pollution by Satellite (MAPS) instruments, will be evaluated on local and urban scales as a part of the tropospheric program. Regional pollutant dispersion models will be coupled to global circulation models in support of future satellite missions. The water pollution monitoring applications will focus on the areas of ocean dumping, red tide research, and lake water quality, including the characterization of eutrophic status of lakes. The following users cooperatively participate in these activities: NOAA and EPA in ocean dumping activities in the New York Bight, the Florida Department of Natural Resources in red tide research, and the EPA in lake quality classification.

BASIS FOR FUND REQUIREMENTS:

WEATHER AND CLIMATE OBSERVATION AND FORECASTING

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
All weather atmospheric sounding experiment satellites (NIMBUS 5 and 6)	9,300	3,500	5,700	900	---	---
Operational temperature sounding satellite (TIROS-N)	7,500	9,000	8,200	2,100	2,100	8,600
Global Atmospheric research program (GARP)	7,200	7,000	7,000	3,000	2,000	6,000
Severe storm program	6,973	8,800	8,800	2,100	2,100	7,100
Applications research and technology development (ARTD)	9,000	11,400	13,000	5,100	3,100	13,000
Follow-on data analysis and operations	---	---	---	---	300	1,600
Cloud imaging from synchronous satellites (SMS 1 and 2)	2,100	---	---	---	---	---
Total	42,073	39,700	42,700	13,200	9,600	36,300

OBJECTIVES AND STATUS:

The NASA Weather and Climate Observations and Forecasting program includes global systems for observation and forecasting of climate variation and change, local forecasting, and fundamental atmospheric processes to provide unique and essential data from space-related technology to national efforts in meteorological research and development.

Present and future operational flight programs will be supported through the development of new instruments and the conduct of specific improvement tasks. This effort involves the provision of advanced sensors, spacecraft subsystems, and ground equipment and techniques specifically in support of ITOS, SMS/GOES, and TIROS-N satellite systems.

The Global Atmospheric Research Program (GARP) is a long-term, international cooperative program designed to advance our knowledge and understanding of atmospheric processes for the purpose of improving the accuracy and duration of our weather forecasting efforts. Weather satellites, with their increasing capabilities to make basic observations, will provide necessary data for global numerical prediction models. NASA is conducting several preliminary Data Systems Tests to study data acquisition and data communication problems and to develop data processing techniques to be used during the First GARP Global Experiment in 1978-1979. Data processing techniques are being developed for determining temperature profiles, sea-surface temperatures, winds (particularly in the tropics), reference-level data, and sea-ice coverage, all on a global basis. This includes collection of global data sets and application of these data in testing current numerical prediction models.

Since climate is a global phenomenon and climate variability often has an adverse impact on man and his activities, space technology and related techniques capable of viewing the entire earth and its overlying atmosphere are uniquely suited to play an essential, major role in any program to cope with the problems of climate change and variability. The "U.S. Climate Program" plan, developed by a special subcommittee of the Domestic Council, emphasizes the urgent need for climate forecast research in view of the impact of climate variability and climate change on the agricultural, economic, and social fabric of the world. In support of the national climate program, space systems will monitor significant meteorological, hydrological, and oceanographic data for the purpose of establishing climatological baselines and for use in climate forecast models of the next decade.

The importance of providing adequate storm warnings to the public for tornadoes, severe local thunderstorms, and hurricanes has been brought into sharp focus in recent years. NASA, in cooperation with NOAA, has built and flown the Synchronous Meteorological Satellites which have been used operationally to assist in public service warnings. NASA is also studying new observing instruments for a 3-axis stabilized geostationary Stormsat system. This satellite system will provide an improved data base for new concepts which must be developed if improvements are to be achieved in the forecasting of short-lived, violent, and destructive storms.

Study efforts are underway on an atmospheric cloud physics laboratory, to further our research on the microphysical cloud processes as they relate to improvements that are so urgently needed in the detection, prediction, and early warning of severe storms.

This program will provide the expertise to investigate basic research areas in radiation transfer, atmospheric models, the earth's energy budget, air-sea interactions, atmospheric composition, and solar radiation. Emerging out of these studies will be future satellite requirements for observing and understanding weather phenomena of various scales. New instruments will be developed under the Applications Research and Technology Development (ARTD) program, demonstrated on specially-equipped aircraft, and become candidate new flight programs.

OPERATIONAL TEMPERATURE SOUNDING SATELLITE (TIROS-N)

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Spacecraft and support	4,482	5,500	5,315	1,700	1,540	6,500
Sensor development	3,018	3,300	2,885	300	405	1,875
Operational station equipment	---	200	---	100	155	225
Total	7,500	9,000	8,200	2,100	2,100	8,600
Atlas-F (Expendable launch vehicles program)	(---)	(3,400)	(3,400)	(---)	(---)	(2,800)

OBJECTIVES AND STATUS:

The objectives of this project are to develop satellites and sensors capable of meeting stated future requirements of the National Oceanic and Atmospheric Administration (NOAA) for obtaining quantitative data of the earth's atmosphere on a daily basis. This data will be used in numerical models of the earth's atmosphere whose solutions are expected to significantly improve long range weather predictions. The sensors will consist of a Basic Sounding Unit to measure the temperature and moisture profiles at several altitudes in the troposphere and lower stratosphere, a Stratospheric Sounding Unit provided by the United Kingdom at its expense to provide similar data in the upper stratosphere, and a Microwave Sounding Unit to obtain atmospheric temperature measurements even in the presence of clouds. The Advanced Very High Resolution Radiometer will provide detailed cloud images as well as sea surface and cloud top temperatures for use in improving the accuracy of 12 to 36 hour weather forecasts. A Data Collection System to be furnished by France at its expense will gather environmental data for central analysis from remote platforms located throughout the world. Finally, a Space Environment Monitor will make daily observations of electron, proton, and X-ray activity in the near-earth space environment. The basic TIROS-N spacecraft and all the above instruments are currently being developed.

CHANGES FROM BUDGET ESTIMATES:

The decrease of $800 thousand in the FY 1976 budget estimate, and adjustments among project elements as reflected in the Transition Quarter estimates, relate to some parts procurement delays and a slower buildup of integration effort than previously planned. However, with minor replanning of the effort this will have no impact on the scheduled early FY 1978 launch.

BASIS OF FY 1977 ESTIMATES:

FY 1977 funding will provide for the development and testing of the instruments which will be completed and the flight units delivered to the spacecraft contractor. Also, the development of the spacecraft will continue and assembly and test will be initiated. The launch is planned in early 1978.

GLOBAL ATMOSPHERIC RESEARCH PROGRAM

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Data systems test support	1,096	874	985	80	240	312
Simulation studies	4,287	4,941	4,931	2,400	1,060	4,170
First GARP global experiment (FGGE)	35	550	578	450	580	993
GARP atlantic tropical experiment support (GATE)	1,615	---	---	---	---	---
Technology support	167	635	506	70	120	525
Total	7,200	7,000	7,000	3,000	2,000	6,000

OBJECTIVES AND STATUS:

The Global Atmospheric Research Program (GARP) is a long-term, worldwide 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 the understanding of the atmospheric physical processes that will lead to improving the accuracy and length of time over which weather forecasts can be made and the understanding of the physical basis of climate. 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 observations and experimental studies of the atmosphere for the design of such models and for testing of model validity.

NASA has been responsible for the Data Systems Test (DST), which is a national effort as a precursor to the First GARP Global Experiment (FGGE) to occur in the 1978-1979 period. The DST focus attention on problems related to the acquisition and processing of global data from many sources, as will be the case in FGGE. In FY 1976 two DST periods, August-September 1975 and January-February 1976, provided global data sets during summer and winter weather conditions. As part of the national effort, NASA was assigned responsibility for the planning of FGGE. A U.S. Plan for Participation in FGGE was completed in August 1975 and is being used as a basic document for developing detailed U.S. implementation plans.

CHANGES FROM FY 1976 BUDGET ESTIMATES:

The decrease of $1.0 million in the Transition Quarter will reduce the number of long range (2-week) forecasting tasks previously planned, and eliminate planned sounder studies using additional DST data.

BASIS OF FY 1977 ESTIMATES:

In FY 1977, DST investigations will continue on the effect of spacecraft data on operational forecasting and on improving the scientific community's capability to assess the new types of global observational data as they become available. Utilizing the DST global data sets, studies will be performed in FY 1977 to improve the current operational forecasting models, which are not able to handle the new observational data well.

In FY 1977, FGGE planning and associated research will be emphasized. Besides the detailed planning, NASA is providing space related development in support of this experiment. The Carrier Balloon System, a joint NASA/NOAA/NSF project, obtains wind profiles over the tropical equatorial belt and will have its final development and testing. Development of an automated aircraft-to-satellite data link to transfer aircraft meteorological data in real-time to the operational forecast center will be completed for use in FGGE global data sets.

Within the GARP, technology is supported to develop new operational methods and to develop techniques for obtaining important weather parameters. In FY 1977, emphasis will be on improved data processing of atmospheric winds, global radiation, rainfall and sea surface temperature measurements as obtained from R&D satellites.

Emphasis will also be focused on developing a climate program based on obtaining global climate parameters such as sea ice and glacier extent, rain rate, amount of cloudiness, sea surface temperature, earth radiation budget, and aerosol concentrations; and conducting studies and experiments to determine the importance of each in measuring and predicting climatic change. An effort will be made to define global initial conditions and making monthly and seasonal forecasts of climate parameters.

SEVERE STORM RESEARCH PROGRAM

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Advanced techniques in observing and forecasting	2,700	2,700	2,700	700	700	2,700
Research and development for improvements to operational satellite systems	2,373	2,400	2,400	500	500	1,100
Stormsat definition studies	---	1,500	1,500	300	300	300
Management of severe storm research data	1,000	1,000	1,000	300	300	1,000
Aircraft support for testing sensors and techniques in severe storm research	600	1,000	1,000	300	300	1,000
Definition of Spacelab payloads for monitoring and detection of severe storms	300	200	200	---	---	1,000
Total	6,973	8,800	8,800	2,100	2,100	7,100

OBJECTIVES AND STATUS:

NASA's goal in severe storm research is to develop and demonstrate space-related capabilities in the detection, prediction, and early warning of violent and destructive storms. The Severe Storms program includes research studies to develop analysis and prediction techniques, specialized aircraft field work, modeling studies, basic research on cloud physics, and satellite system development.

Efforts to specify sensor characteristics and to improve physical measurement concepts for detecting and locating tornado origins will be continued. Delivery was made in the latter part of FY 1976 on the new, man-machine interactive system, the Atmospheric and Oceanographic Information Processing System (AOIPS). This system, which is essential to our study of the characteristics features of severe storms, will be used for the management, display, and enhancement of meteorological data from various sources for the purpose of developing severe storm detection and prediction models and for improving the basic understanding of severe storm characteristics. With the launch of the GOES-A satellite in October 1975, we have achieved an operational capability to monitor severe storms, such as tornadoes, hurricanes and extra-tropical cyclones, over the U.S. and its adjacent marine areas.

BASIS OF FY 1977 ESTIMATES:

FY 1977 funds will provide for the support of NASA aircraft operations which will include specialized flights for the study of characteristics of storm-producing cloud systems. Also, concurrent satellite and special ground-based observations will be obtained to provide a complete 3-dimensional description of the storm and its environment. These data are essential for the development of prediction techniques and for validating severe storm models. Efforts will continue toward modeling the growth, movement, and behavior of tornadoes, severe thunderstorms, and hurricanes. NASA will make the data available to the research community. Also in FY 1977, studies, including preliminary design, of an atmospheric cloud physics laboratory will be conducted. This payload, which could be flown on an early Spacelab mission, is designed to increase significantly our current knowledge of the micro-physical cloud processes. These processes must be understood better if we are to make urgently needed improvements in the detection, prediction, and early warning of severe storms.

In FY 1977, satellite-related efforts will focus on the completion of the SMS/GOES Visible and Infrared Spin Scan Radiometer (VISSR) Atmospheric Sounder (VAS) instrument which will be on GOES-D. Studies for defining the mission-unique items for the 3-acis stabilized Stormsat spacecraft will be completed. Stormsat, as it is currently being defined, would carry the Advanced Atmospheric Sounding and Imaging Radiometer (AASIR) instrument which will be a second-generation radiometer based on the technology of the VISSR and VAS.

APPLICATIONS RESEARCH AND TECHNOLOGY DEVELOPMENT (WEATHER AND CLIMATE)

	1975	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
			(Thousands of Dollars)			
Advanced techniques in observing and forecasting	2,500	3,000	4,200	1,700	700	3,000
Research and development for improvement of operational satellite systems	900	2,600	3,000	1,900	1,200	3,400
Exploration of the atmosphere using meteorological sounding rockets	1,500	1,900	1,900	600	400	2,100
Development of advanced flight experiments for research in weather and climate	1,100	1,600	1,600	200	100	1,600
Aircraft support for development of techniques in observing and forecasting	1,900	1,300	1,300	400	400	1,600
Studies in application of weather and climate observation and forecasting systems	1,000	1,000	1,000	200	200	1,000
Spacelab payload definition	100	---	---	100	100	300
Total	9,000	11,400	13,000	5,100	3,100	13,000

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OBJECTIVES AND STATUS

The objective of this project is to develop and demonstrate the application of space-related capabilities to the improvement of weather forecasting and climatic change determination. This includes investigations to provide an understanding of the basic physical processes which affect weather, the development and demonstration of techniques for the prediction of weather and climate changes, and the development of improved remote sensors and advanced systems to observe key weather parameters and the factors which influence the earth's climate.

In particular, important emphasis in the future will be on accelerating essential research on climate variability and change. Key elements have been identified and are being studied: global energy balance--the significant climatic effects resulting from the rate at which we gain energy from the sun versus the rate at which we lose energy to space; the energy interactions between the atmosphere, solid earth, and the oceans; the effects of gases and particulates, both natural and man-made, on the radiation balance of the earth; and the role of changing land surfaces.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate: The increased funding of $1.6 million is attributable to increased support required by efforts directed mainly toward climate modeling and the development of an improved climate observational capability.

Transition Quarter Estimate: The decrease of $2.0 million in the Transition Quarter reflects adjustments resulting from the general congressional reduction in NASA's R&D budget request for this three month period. This reduction serves to delay until FY 1977 the start of new research efforts in synoptic-scale weather phenomena and the use of such data in the modeling of atmospheric motions. Also, a similar delay will be experienced in the development of improved subsystems and sensors for the operational flight programs.

BASIS OF FY 1977 ESTIMATES:

Studies of the basic physical processes involved in how weather systems develop, grow, and dissipate will continue. These studies will require the development of new techniques for extracting key parameters from the remotely-sensed data and the development of models which will simulate the atmosphere and the processes taking place.

The development of advanced microwave remote sensing techniques, advanced earth and solar radiation measuring instruments, and meterological radar will be continued. Calibration and preliminary testing of new instruments will be performed on NASA aircraft in order to specify the requirements for future improved satellite instruments and systems and to provide unique data to support research efforts.

Efforts will continue on the definition of a radiation budget satellite system and the space components of a comprehensive climate program. The development of a precision solar constant monitor for the Solar Maximum "Mission" will be started.

Operational Satellite Improvement, efforts will be conducted that involve the provision of advanced sensors, spacecraft subsystems, and ground equipment and techniques specifically in support of the ITOS, SMS/GOES, and TIROS-N satellite systems.

Follow-On Data Analysis and Operations (Weather and Climate)

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
NIMBUS follow-on operations.....	---	---	---	---	300	1,600

OBJECTIVES AND STATUS:

The objective of this effort is to provide continued support for ground-based efforts to insure efficient utilization of data collected by various types of remote sensors. This includes balloon, aircraft, rocket, and satellite sensors for which development and flight resources support had run out due to the extended lifetimes of the hardware. Data analyses, data-use studies, and support of various programs will continue by providing additional data vital to the success of that program. In some cases, new analyses of previously-examined data can provide improved results when combined with additional data collected through the extended lifetime of the NIMBUS-5 and -6 sensors.

CHANGES FROM BUDGET ESTIMATES:

The increase of $300 thousand in the Transition Quarter provides for continued flight operations of the NIMBUS-4, -5, and -6 spacecraft. Funding for these requirements had not been previously provided for in the NIMBUS program. Current flight project funding is sufficient to support only one year's operations.

BASIS OF FY 1977 ESTIMATES:

The FY 1977 funds will provide for the operation of the NIMBUS Control Center, as well as data reduction and analysis effort for which urgent needs continue beyond the first year of flight. These data include global total ozone measurements from NIMBUS-4; global precipitation, soil moisture and snow-and-ice cover cover data from the microwave sensors of NIMBUS-5; and data on the earth's radiation budget from NIMBUS-6.

Included will be the development of special data processing techniques and software for the new interactive mini-computer system, Atmospheric and Oceanographic Information Processing System (AOIPS).

Such data, when properly reduced to useful physical parameters and furnished to the scientific and data-user community, will be applied directly to specific national and global problems, such as the stability of the earth's ozone layer, the trend of regional and world climates, severe storm analyses and prediction, and land-use-change detection.

BASIS OF FUND REQUIREMENTS:

MATERIALS PROCESSING IN SPACE

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Applications research and technology development	4,200	4,700	5,100	1,100	1,000	6,300
Space processing rocket experiment project	400	600	600	300	200	2,900
Total	4,600	5,300	5,700	1,400	1,200	9,200

OBJECTIVES AND STATUS:

NASA's program on Materials Processing in Space is intended to develop useful applications of space flight for materials science and technology and to permit commercial space activity to take advantage of such applications.

Preliminary experiments on the Skylab and Apollo-Soyuz Test Project (ASTP) missions as well as ground based studies have indicated that processing of materials in space can be a cost effective approach to basic and applied materials research. In addition, some types of products have been identified that may be economical to manufacture in space for use on earth, such as biological preparations and electronic materials. Experimental work in these areas is planned to continue on a series of ballistic rocket flights. Study efforts, including preliminary design, will be initiated in FY 1977 to provide a basis for space processing payloads that will take advantage of the unique capabilities offered by the Spacelab.

Work in the biological area has been centered on development of means to separate living cells according to their electrical characteristics by a method known as electrophoresis. Applications for living cells prepared in this way include direct therapeutic uses such as cell transplanation to restore certain lost

functions of the body, incubation of cell cultures to make products that have medical and other uses, and research studies to identify the physiological functions of individual cell types.

Another promising potential for space processing is in the electronic materials area, which involves growth of single crystals because most electronic materials are used in this form. It is expected that space techniques can be developed to produce electronic crystals with higher perfection and more uniform properties than can be obtained on earth because conditions in molten and vaporized materials can be controlled more precisely under conditions of weightlessness. In addition, prospects exist to control the shapes of growing crystals so as to produce them in the forms needed for final use, with highly perfect native surfaces on which high quality electronic devices can be formed. Recent economic studies of products based on these possibilities indicate that profitable production operations would be feasible.

In addition to these major areas, space conditions will be useful for applied research and possibly for specialized product development in a variety of other fields. For example, there appear to be some specialized metallurgical products of small size and high value that can be manufactured profitably in orbit, such as high performance tungsten anodes for high power X-ray tubes, and the ability to perform heat treating processes on unsupported materials without containers will enable ceramists and glass technologists to explore materials compositions and process variables that cannot be treated by methods available on the ground. Analogous potentials exist in fields such as electrochemistry, fluid mechanics, polymers, and other areas.

All of these prospects require low cost, easily accessible processing capabilities in orbit. Space processing studies, investigations and analysis of potential applications will be continued and will include synthesis of space experiment results to identify potentials that are not predictable from ground data alone. The flow of space experiment results will be continued in 1977 and beyond through augmented effort in the Space Processing Rocket Experiment Project, which will also offer opportunities for commercial users to fly proprietary experiments at their own expense. Space processing payload studies will be initiated in FY 1977.

APPLICATIONS RESEARCH AND TECHNOLOGY DEVELOPMENT (MATERIALS PROCESSING)

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Ground based materials processing investigations, analysis and studies	2,900	3,100	3,500	900	800	4,500
Advanced materials processing system development	500	500	500	100	100	500
Space processing systems analysis	300	300	300	100	100	300
Spacelab payload definition and preliminary design	500	800	800	---	---	1,000
Total	4,200	4,700	5,100	1,100	1,000	6,300

OBJECTIVES AND STATUS:

The Applications Research and Technology Development (ARTD) project supports several major functions in the Materials Processing in Space activity. Laboratory research and related studies to identify promising space processing applications and investigate the implications of past flight experiments comprise the principal ARTD activities. In addition, the project supports feasibility and definition studies for future flight experiments, and efforts to develop technology for advanced materials processing equipment. It also includes studies to assess the economic feasibility of future applications that show technical promise.

These studies, investigations, and analyses provide the basic information needed to select future flight activities in the space processing program, plan experiments, and investigate the implications of their results. During FY 1976 about 30% of the effort is devoted to initial development of experiments for the Space Processing Rocket Experiment Project. Ground-based studies cover a wide variety of topics, including growth of metal and semiconductor crystals, development of containerless processing methods for improved laser glass, measurements of the properties of human cells that govern the feasibility of separating pure preparations of the various types, and similar subjects. Economic studies were performed in cooperation with potential commercial user organizations on metallurgical, electronic and biomedical applications of space processing.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimates: The increase of $400 thousand in the FY 1976 funding results from the augmentation of ARTD effort associated with the Rocket Experiment Project, to meet the continuing needs for experiment definition before commitment to flight and to provide for synthesis of a coherent data base from experiment results.

Transition Quarter Estimates: The decrease of $100 thousand in the Transition Quarter reflects adjustments resulting from the general congressional reduction in NASA's R&D budget request for this three-month period.

BASIS OF FY 1977 ESTIMATES:

All of the space processing flight experiments have been based on processes whose potential was first identified by ground based research, and most have depended for their implementation on basic technology developed in prior ground based projects. In addition, the experiment requirements used for preliminary definition of space processing payloads have resulted from ground based investigations and the sounding rocket experiment project initiated in FY 1975.

FY 1977 funds will provide for continued study efforts, including preliminary design, on materials processing experiment equipment for Spacelab payloads, in preparation for the beginning of hardware development in the following year.

With the advent of full scale experiment operations in the rocket project and study activity for Spacelab payloads, supporting research studies and technology development on the ground will continue to be essential to the functioning of the Space Processing Program. Areas to be covered in the Applications Research and Technology Development activity will include: (1) Definition and design of systems to separate biological samples in the near weightless environment provided by the rocket flights; (2) Identification and ground based studies of new space applications in electronic metallurgical, and ceramic materials; (3) Review and correlation of results from the initial three rocket missions; (4) Design and development of prototype advanced technology materials processing apparatus; and (5) Analysis of future markets associated with space product applications of electronic materials and biological preparations.

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SPACE PROCESSING ROCKET EXPERIMENT PROJECT

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Vehicle and launch support	400	600	600	300	200	900
Payloads	---	---	---	---	---	2,000
Total	400	600	600	300	200	2,900

OBJECTIVES AND STATUS:

The Space Processing Rocket Experiment project conducts a program of materials processing experiments on ballistic rocket flights to support continuing development of space applications and expand the available fund of experimental data on processes in weightlessness. These activities will contribute directly to the design of Shuttle/Spacelab experiments and equipment. The flight opportunities provided by the rocket project will also serve to introduce prospective Spacelab users to space experiment techniques and establish efficient management methods for repetitive low cost experiment operations.

Experiment operations were initiated under this project in 1975 with experiments supported by the Advanced Research and Technology Development project. An Announcement of Opportunity soliciting experiment proposals was issued early in the year and 62 responses were received, covering topics in metallurgy, electronic materials, glass technology, biological preparations, and physical and chemical processes in fluids. Sixteen were selected for flight, and the first rocket mission was flown successfully on December 11, 1975. The payload processed samples for nine Principal Investigators. Two more flights will be conducted during the rest of FY 1976 and the Transition Quarter, and a second Announcement of Opportunity will be issued early in CY 1976.

The cost effectiveness levels now expected for rocket experiments appear to be in a range that could be attractive for some industrial research purposes. Therefore, the new Announcement of Opportunity for the project includes an explicit offer to fly industrial experiments at the expense of commercial sponsors, under arrangements permitting the sponsors to retain proprietary rights to the results.

CHANGES FROM BUDGET ESTIMATES:

The decrease of $100 thousand in the Transition Quarter reflects adjustments resulting from the general congressional reduction in NASA's R&D budget request for this three-month period, and will require an adjustment to the rocket flight schedule.

BASIS FOR FY 1977 ESTIMATES:

The FY 1977 funds will provide for sounding rocket flights to develop space processing techniques, and to process the returned data. The initial rocket flight was flown in December 1975, and the launches will continue at approximately three per year through 1980. This program will involve multiple investigators performing iterative research programs with reusable equipment, and flights will be scheduled in response to experiment requirements. In these respects it will be similar to the space processing project planned for the Shuttle/Spacelab.

In the first year of the Rocket Experiment Project it was found that the average rocket flight can support about twice as many investigators as had been estimated originally. In addition, the scope for individual experiments has proved to be larger than expected at first. Consequently, there has been a substantial increase in the productivity of the rocket flights and the flight costs associated with the average individual experiment have been reduced to attractively low levels. It has been necessary to increase the level of support allocated to experimenters to utilize the system most effectively, and this level of effort is beyond what can be provided from the Applications Research and Technology Development project. Therefore, the budget for FY 1977 includes funds specifically for payloads within the rocket project.

BASIS OF FUND REQUIREMENTS:

Space Communications

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	Budget Estimate
			(Thousands of Dollars)			
Cooperative Applications Satellite (CAS-C)	1,550	1,100	1,100	100	100	300
Technical consultation and support studies	1,650	2,100	2,100	600	500	2,600
Spacelab payload development	---	---	---	---	---	1,200
Applications research and technology development	2,600	2,100	2,400	900	700	2,800
Follow-on data analysis and operations	6,200	2,900	4,400	800	600	3,700
Total	12,000	8,200	10,000	2,400	1,900	10,600

OBJECTIVES AND STATUS:

The objective of this program is to develop and demonstrate applications of communications technology from which will come future commercial and public service initiatives. NASA's efforts for FY 1977 include continuing support of the Indian Satellite Instructional Television Experiment, SITE, using the ATS-6 spacecraft; operation of the Cooperative Applications Satellite-C, CAS-C; the development of communications concepts and technology anticipating future commercial applications; and the conduct of special communications studies and experiments to support our statutorily required technical consultation services.

The SITE activity, which began with ATS-6 following a year of very productive experimentation domestically, is progressing well. This year long experiment provides 4 hours of programming daily to about 5,000 remote Indian villages. The programs are educational in content and deal with family planning, basic hygiene, agricultural practices and national development. The Indian developed ground equipment is working very well and the locally produced programming is being enthusiastically received by the villagers.

The launch of the Cooperative Applications Satellite-C, CAS-C, following eighteen months of highly successful demonstration of direct satellite broadcasting with ATS-6, opens a new era in this important

field. This is a cooperative effort with Canada, in which NASA provided the advanced high powered communications transmitter, much spacecraft testing and launch services in return for half-time use of the spacecraft. Used experimentally to provide sociometric, technical/scientific and other communications programming, CAS-C represents more nearly a prototype of a satellite that could provide operational television broadcasts direct to individual receivers in a frequency band allocated specifically for that purpose. As such, the experiment program involving this spacecraft will provide very important information and experience toward the consideration of widespread use of direct satellite broadcasting.

Although U.S. industry currently enjoys a dominent position in the world market for communications satellites and related technologies, significant foreign competition is developing rapidly. Japan, Germany, and other foreign countries are sponsoring developments of satellite technology that will demonstrate operationally direct broadcasting to small, individual receivers during the next several years. Japan is well along with its development.

NASA's effort in space communications research is concentrated on developing and demonstrating technology that will help maintain a U.S. position of leadership.

The trend in satellite communications technology is toward smaller and cheaper earth terminals, both fixed and mobile. Development of associated satellite systems will require that NASA conduct research in high-power transmitters, sensitive receivers, and other essential system components, such as antennas which will permit commandable, adaptive beam contouring, to confine transmissions to selected geographic areas. New types of modulation and bandwidth compression techniques will be used in experiments to illustrate that our existing allocated bands can be used more efficiently. Combinations of these techniques will be studied to define and demonstrate optimum systems.

The technology base is thus being laid for a new family of satellite services that could be implemented in the 1980-1990 time frame. These include: (1) Disaster Warning Satellite to provide the National Oceanic and Atmospheric Administration (NOAA) with improved communication systems to help minimize losses from natural disasters; (2) Satellite aided Search and Rescue to provide improved methods of detecting a distress alert from aircraft, ships and other vehicles, including their approximate location on a global basis; (3) Collection of environmental and resources data by satellite from thousands of floating or fixed unattended platforms situated around the globe for retransmission to user or NASA ground stations; (4) aeronautical and maritime communication and position location services, and (5) broadcast satellites with interactive communications capabilities such as two-way video and voice to be used to deliver educational, health care or other sociometric services. As this new technology is developed, experiments will be conducted to demonstrate the potential usefulness and cost effectiveness to the user community of such services. An orderly transition will permit the new service to evolve from experimental to quasi-operational to an operational status.

We expect subsequent generations of communications satellites to continue these trends bringing high quality, low-cost communications to such diverse applications as mobile and personal uses. These applications are expected to feature wide-spread use of minimal terminal equipment.

These services will impose demands for frequency allocations that will increasingly aggravate the already crowded spectrum in the lower frequency ranges. The solutions to such problems are found in coordination of users needs to prevent interference and in development of techniques and devices that permit much more efficient use of the frequency band available. While NASA's efforts in FY 1977 are heavily concentrated on relieving further over-crowding in already widely used bands, a longer range interest is devoted to developing technology to open higher, as yet, unused frequencies.

Cooperative Applications Satellite-C (CAS-C)

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Spacecraft testing	470	620	620	---	---	---
Experiments and operation	980	330	330	100	100	300
Mission analysis	100	150	150	---	---	---
Total	1,550	1,100	1,100	100	100	300
Delta (Expendable Launch Vehicles program)	(3,300)	(---)	(600)	(---)	(---)	(---)

OBJECTIVES AND STATUS:

CAS-C is a cooperative program between NASA and the Canadian Department of Communications, whose principal objective is to demonstrate satellite broadcast communications in sociometric, technical/scientific and other communications applications. The satellite features a NASA developed, highly efficient and powerful transmitter which permits television reception with small, 2 meter diameter antennas. Designed to operate in the 12 GHz frequency band, this satellite is of particular interest since the frequency is specifically for satellite broadcasting and there are no restrictions on power levels. In addition, it is in an uncrowded region of the frequency spectrum, and experimentation in this frequency is considered urgent in view of forthcoming domestic satellite systems which will further crowd the spectrum below 10 GH_z. The CAS-C spacecraft launch is planned for early 1976.

BASIS OF FY 1977 ESTIMATES:

The FY 1977 funds will provide for conducting NASA communications experiments, and for technical support of U.S. communications experimenters using CAS-C. This support will consist of coordination of experimente use of satellite time, and testing of new experimenter ground equipment to ensure compatibility with spacecraft. Funds will also be used for operation of the Lewis Research Center ground stations which will monitor in-orbit performance of the transmitter experiment package -- the prime technology experiment on CAS-C.

Technical Consultation and Support Studies

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
1,650	2,100	2,100	600	500	2,600

OBJECTIVES AND STATUS:

This program, authorized by statute, provides consultation and special studies for Government and other organizations in spacecraft and telecommunications technology. Studies and experiments being performed help provide technical and regulatory frameworks to allow growth of existing satellite services and provide for the inclusion of new satellite applications.

The technical consultation effort is grouped into two main categories, orbit and spectrum utilization and satellite systems support. Orbit and spectrum utilization includes: (a) the development of techniques and strategies for geostationary and non-geostationary orbit and radio frequency spectrum sharing; technical standards for orbit and spectrum use; equipment design criteria for more efficient use of the orbit and specturm, and (b) the determination of the effects of propagation phenomena and man-made noise on performance, design, and orbit and spectrum utilization of space telecommunication systems. Satellite systems support includes design and flight readiness reviews and technical assessments on Intelsat and Domsat systems for the FCC, and special studies on high priority FCC and NASA program office requests.

During FY 1976 a number of high priority tasks were initiated in preparation for the 1977 World Administrative Radio Conference (WARC) on Broadcast Satellites and the 1979 WARC for revision of the International Radio Regulations. On a regional and global basis, the WARCs will deal with the allocation of the radio frequency spectrum for all space and terrestrial telecommunications services and establishment of technical standards, design criteria and operational procedures. The 1979 WARC will feature the most

comprehensive and critical revision to the International Radio Regulations since 1959. The 1977 and 1979 conferences will have long range effects on the development of future space communications possibly through the year 2000 and may also result in major impacts on existing systems. The preparations of more than 50 technical papers which will serve as key inputs to the 1977 and 1979 WARCs and for domestic regulatory purposes have been supported by this effort.

CHANGES FROM THE TRANSITION QUARTER BUDGET ESTIMATE:

The decrease of $100 thousand in the transition quarter reflects adjustments resulting from the general Congressional reduction in NASA's R&D budget for this three month period. This decrease will delay the completion of the propagation measurements and associated analyses required to support the 1977 WARC.

BASIS OF FY 1977 ESTIMATES:

The FY 1977 funds will provide the assistance requested by the Federal Communications Commission (FCC), the Office of Telecommunications Policy (OTP) within the Executive Office of the President, and the Department of State, who have asked NASA to play a major role in the preparations for the 1977 and 1979 WARCs. More than 50% of the technical preparations for the 1977 WARC as well as major contributions to the 1979 WARC will be provided.

As more and more space systems are planned and implemented and additional ground stations and satellites are placed in service, questions of sharing will be come more serious particularly since virtually all radio frequencies up to 40 GH_z have been allocated to terrestrial services. The usefulness of higher frequencies as well as the more efficient use of bands below 40 GH_z is highly dependent on the outcome of studies to be performed by NASA addressing questions such as: radio frequency interference between satellite systems, interference between satellite and terrestrial systems such as radio astronomy and mobile services, satellite spacing, positioning and repositioning, transmitter power levels, spill-over patterns of applications satellites, spectrum and orbit congestion and the adverse effects of propagation phenomena.

Spacelab Payload Development

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Total payload development.....	---	---	---	---	---	1,200

OBJECTIVES AND STATUS:

The objective of the Spacelab Payload Development Program is to develop promising communications payloads to take advantage of the unique capabilities of the Space Shuttle and Spacelab missions in the early 1980's time period.

BASIS OF FY 1977 ESTIMATES:

The FY 1977 funds will provide for the following communications payloads:

(1) A radio frequency survey experiment to provide selected spectrum monitoring. These data are needed by NASA to provide technical advice to the FCC and OTP for future domestic frequency allocations.

(2) A bandwidth compression modulation transmitter. This is an important approach to handling the large volume of digital data expected to be sent to earth from applications experiments in the 1980's. Compression ratios of about 6:1, when compared with conventional techniques, is the experiment goal.

(3) An adaptive multi-beam antenna that will provide a significant improvement in the radiated power that could be received by ground-based communications systems. This type of spaceborne antenna has direct application to future geostationary altitude communications satellites being considered for broadcasting applications to education, health care, delivery and postal services and for small mobile terminals, such as might be used on trucks and autos, and data collection platforms.

(4) An open envelope traveling wave tube experiment to determine feasibility of building tubes of greater efficiency and reliability.

Applications Research and Technology Development (Space Communications)

	1975	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
			(Thousands of Dollars)			
Advanced communications research.....	1,600	1,400	1,700	500	400	1,900
Development of advanced flight experiment for communications research.	100	100	100	100	100	100
Studies in applications of communications system.....	400	400	400	200	100	300
Spacelab payload definition and preliminary design.....	500	200	200	100	100	500
Total.....	2,600	2,100	2,400	900	700	2,800

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OBJECTIVES AND STATUS:

The Applications Research and Technology program consists of studies, development programs, and experiments which provide technology, potentially of high public value and not otherwise occurring in the private sector. The effort maintains the NASA position as the center of Government expertise in non-defense-related space communications and serves NASA's own needs for space communications development. Program objectives include: more efficient use of the available electromagnetic spectrum; expansion of communications capability into presently unused and uncluttered parts of the spectrum; developing technological solutions for radio interference problems; generating improvements in radio-location technology for use in tracking, collision avoidance, and search and rescue; and the development of improved-performance components with lower cost. The spectrum efficiency and interference reduction improvements are being met by bandwidth compression techniques, new methods of forming the antenna beam, and techniques for doubling the number of channels on the same frequency by using different polarizations. Improved communications devices are being developed in the millimeter wave band for use in the future, as well as the progress being made in low-cost, highly reliable and efficient conventional frequency components. All of these developments are expected to have commercial applications with high economic value.

CHANGES FROM BUDGET ESTIMATES:

The increase of $300 thousand in the FY 1976 budget estimate is to complete a preliminary design study for a satellite system that would provide a disaster warning service.

BASIS OF FY 1977 ESTIMATES:

The FY 1977 funds will provide for the completion of the ongoing effort. Also, in FY 1977 studies will begin on technology required for advanced communication capabilities. In the preparation for the use of new, efficient, multiple small user satellite communications, new techniques for access to the satellite radio link, and very large antennas which can provide small terminals with adequate receiver power will be studied and developed. The use of bandwidth compression will be generalized to permit obtaining needed higher data rates for future satellite use in many different ways. The need for the reduction in cost and size of small user terminals will require powerful transmitters and large, deployable antennas in space. The thorough understanding of these technologies is critical to the near future of space communications research, as rewarding commercial opportunities of the 1980's are believed to be in this area. The definition of a large, deployable antenna, and experiment which will test a millimeter-wave antenna concept, and a space-to-ground energy transfer experiment for the Shuttle will be initiated in FY 1977.

Analyses of the data collection results from a joint NASA-California Division of Forestry experiment in the remote collection of weather data indicative of forest fire onset will be started, as will the study of advanced spaceborne concepts for future low-altitude and synchronous orbit data collection systems.

Follow-On Data Analysis & Operations (Space Communications)

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Follow-on data analysis & operations	6,200	2,900	4,400	800	600	3,700

OBJECTIVES AND STATUS:

The objective of this program is to provide a capability for a full spectrum of experimentation in the application of satellite communications. NASA has a number of experimental communications satellites in orbit, two of which have the unique capability of broadcasting high quality television into small, low-cost terminals. Experiments conducted with these spacecraft both here and in India show that additional broadcast demonstrations are needed and in demand by the user community. CAS-C, to be launched in early 1976, has 13 approved experiments and ATS-6 has some 12 proposlas in hand and expects 15 more. Under the procedures established earlier, 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.

CHANGES FROM BUDGET ESTIMATES:

Changes in FY 1976 Estimates: The increase of $1,500 Thousand is to support ATS-1, -3, and -5 activity, experiment support for the CAS-C, and third-year of ATS-6 experiments.

Changes in Transition Quarter Estimate: The decrease of $200 Thousand reflects adjustments resulting from the general Congressional reduction in NASA's R&D budget request for this three month period and requires a reduction in the amount of experimenter support.

BASIS OF FY 1977 ESTIMATES

The FY 1977 funding will provide for the ATS-1, -3, and -5, continue support of autonomous experimentation and in support activitites to the CAS-C and ATS-6 experiments programs. Some thirty autonomous experiments, and some fifteen to twenty ATS-6 and CAS-C support activities are anticipated. By the start of FY 1977 the CAS-C experiments program will have already been underway for a half year. It will continue throughout FY 1977 with the involvement of some twenty-five independent experiments. The start of FY 1977 will also see the third year of ATS-6 experiments with an expected complement of some twenty to twenty-five experiments.

BASIS OF FUND REQUIREMENTS:

Information Management

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
Total information management.....	3,200	3,200	3,200	1,300	800	3,200

OBJECTIVES AND STATUS:

Very high data rates with volumes up to 15 times those of Landsats 1 and 2, and stringent timeliness and accuracy requirements for information products, are significant challenges to data and infomation systems designers. The principal emphasis is on the data processing needed by Weather and Climate, Severe Storm Research, Earth and Ocean Dynamics, and Water and Earth Resources programs, as these become demonstrations and verifications of potential operational services for NOAA, USDA, and the Corps of Engineers. The objective is to achieve cost-effective information systems by understanding needs of users and systems designers, producing techniques to maximize the value of data being collected for recipients, and by working with all concerned in an integrating role. General goals are to model total data/information systems for NASA programs (e.g. to assure adequate capability), to demonstrate data compressibility (elimination of unneeded data for more cost-effective results), and to advance promising data technology to system-ready status. Specific goals are to: improve information extraction processes; improve the definition of data needs; improve information handling; and enhance the timeliness of information dessemination to satisfy total information management requirements of the end user.

To date, the program has produced such visible results as the Atmospheric and Oceamographic Information Processing System (AOIPS). The AOIPS will be used for information processing research, for management of data from SMS/GOES, Nimbus-6, and Landsat; and for preflight experiments on Nimbus-G, HCMM, and Seasat. This system includes interactive image-display systems for information extraction and will be fully operational in FY 1976. Also a system engineering and analysis capability to detect and solve likely data bottlenecks was established. The Seasat-A Program is the first to be modeled and simulated from end-to-end to assure its total integrity and capacity. Software to model the data flow from sensor output to final users will be exercised. Different system condifurations and performance characteristics will be represented to derive cost and performance-optimized designs. The approach is to study program data needs, and the techniques which will be necessary to satisfy them, followed by system analysis and modeling of systems. Experimental operations (simulations) will be conducted to refine the system models. Full consideration will be given to programmatic requirements (both user and operational). High priority missions/programs data systems will be modeled. A library of computer software for analyzing and compressing space-derived Earth Observation data has been assembled and critical assessment is underway. Experiments at several

Centers have shown that significant reductions in volumes of sensor data to be transmitted, to be processed, and to be stored can be achieved using compression techniques. Finally, several approaches to producing data bases, data base structures and data base management systems for such user communities as part managers, agricultural crops surveyors, water resource-flood control managers, and city planners are in various states of completion, from conceptual design to quasi-operational.

CHANGES FROM BUDGET ESTIMATES:

The decrease of $500 thousand in the transition quarter reflects adjustments resulting from the general Congressional reduction in NASA's R&D budget request for this three month period. This decrease results in a stretchout of data base management activities and compression/classification technique assessment, and a postponement of the high density/high capacity storage system studies.

BASIS OF FY 1977 ESTIMATES:

The FY 1977 funds will provide for greater refinement of models to simulate Seasat data systems and other large data producing programs. Simulations will be more detailed, permitting evaluation and selection of system components for desired characteristics. Studies, experiments and demonstrations of how to couple the information users, the information system designers, and concepts or prototypes of systems for best total end-to-end data and information system cost-effectiveness will be performed in Land Use, Earth Resources, Pollution Monitoring, and Water Resources program contexts.

A number of competitive data compression methods for faster information analysis will be evaluated to establish the most cost-effective combination of data, analysis methods, and information products for different applications. These methods either greatly reduce redundancy in sensor-generated data, or the information content to a controllable extent, or both. The program will establish the actual utility of some techniques relative to cost and complexity. Data transmission costs can be kept low while information rates are sufficiently high for critical time-limited applications such as flood prediction for large river basins.

Storing large amounts of information quickly, conveniently, cheaply, and permanently, with easy retrieval capability to speed dissemination, has accompanied the knowledge explosion. Remote sensing on a global scale around the clock has accelerated that quest. Demonstrating relatively low-cost (ground-based) storage systems to meet requirements of Landsats 1, 2, and C, Seasat, and other missions in the foreseeable future is a program objective. One of the techniques to be evaluated is the exploitation of the dynamic range of magnetic tape by multi-level techniques which utilize variable, but discrete magnetic intensities. Factors of four or better in capacity and speed are anticipated.

Data base management systems for Natural Resources, for Landsat imagery retrieval, for the Large Area Crop Inventory Experiment, and for State/Local Earth Observation-derived information users will be demonstrated and transferred to sponsoring agencies. A five state (Missouri, Minnestoa, Wisconsin, Illinois, and Iowa) study by Washington University is to be continued after outlining alternative information dissemination approaches to meet user needs. The City University of New York has completed the user needs phase of the Three States Area (New York, New Jersey, Connecticut) study and will propose models and prototype data bases and data base management systems by which data and/or information is stored to facilitate easy retrieval, display, and transfer.

BASIS OF FUND REQUIREMENTS:

Applications Explorer Missions (AEM)

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Heat Capacity Mapping Mission (AEM-A).....	2,588	3,500	3,500	600	500	2,200
Stratospheric Aerosols and Gas Experiments (AEM-B).....	---	2,400	2,400	2,000	1,700	6,100
Magnetic Field Satellite (AEM-C).....	---	---	---	---	---	2,000
Total.....	2,588	5,900	5,900	2,600	2,200	10,300
Scout (Expendable Launch Vehicles program)	(---)	(---)	(---)	((---)	(---)	(2,400)

OBJECTIVES AND STATUS:

Frequently we come upon very valuable concepts for gathering information needed to support the Applications Programs. This information often can be obtained by flying a very small, relatively low cost satellite of standard configuration using our lowest cost launch vehicle. Therefore, the Applications Explorer Mission (AEM) Program was established to develop low-cost, Scout-launch spacecraft tailored to specific areas of research and orbital requirements. This program already has systems under development to support objectives in the environmental quality and earth resources survey area, and we are proposing to support the earth dynamics discipline in FY 1977 with the start of the Magnetic Field Satellite.

The first mission, the Heat Capacity Mapping Mission (AEM-A), will obtain temperature data, an identifiable characteristic of various materials, to develop heat capacity maps of rock types for applications

to mineral potential assessments. Data acquired with this mission 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 early 1978 into an orbit which will allow complete day/night coverage of the United States every eight days and will permit the collection of pre-dawn and early afternoon data. The instrument to be used is based on the adaptation of a spare Nimbus-5 flight instrument.

The second mission, the Stratospheric Aerosol and Gas Experiment (AEM-B), will help develop measurement techniques for the detection and mapping of stratospheric aerosols and ozone by observing the attenuation of the solar radiation through the Earth's atmosphere. Stratospheric aerosols and ozone concentrations can be altered by natural causes and by man's activities. These measurements are 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 controlling the Earth's climate. In addition, knowledge of the variations in the ozone blanket is important because of the protection from extreme ultraviolet radiation which this blanket affords. This mission, to be launched in 1979, will provide bi-weekly coverage of aerosols and ozone for low and mid latitudes. 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 aerosols which are important to the studies of the stratosphere.

The third mission, the Magnetic Field Satellite (Magsat), AEM-C, is planned for launch in 1980, and is intended to map the magnitude and direction of the Earth's global magnetic field with improved accuracy. Magsat data are needed to refine magnetic field models and charts, to update current magnetic field data by accounting for secular changes, and to investigate the feasibility of using magnetic field data for resource exploration. Recent analysis of magnetic field measurements obtained by the U.S. Orbiting Geophysical Observatory satellites and U.S.S.R. Cosmos satellites indicates that the International Geomagnetic Field model is substantially in error over large areas. These errors arise from a scarcity of geomagnetic measurements and time variations of the Earth's field. These satellite data, although of limited accuracy, have resulted in the identification of near-surface field changes which are believed to be associated with variations in the Earth's crust and which may be indicative of resource deposits. The Magsat mission will provide several global surveys of the Earth's field in a relatively short period (about eight months) and with substantially improved accuracy. This information will be used by the U.S. Geological Survey (DOI) to demonstrate the use of space-acquired magnetic field data to meet national commitments for periodic updating of regional and global magnetic field charts and to develop an accurate model of the Earth's main magnetic field. The global field models will be used to identify areas where the local field differs from the model. Studies of these different or anomalous areas are expected to provide useful information for geophysical resource prospecting and assessments of natural resources such as coal, oil, and minerals.

The Magsat mission will use the spacecraft bus concept under development for the earlier Applications Explorer Missions. The instruments, a scalar magnetometer and a three-axis vector magnetometer, will be

mounted to a long boom to minimize the effects of any spacecraft induced magnetic fields. In order to achieve the accuracies required, the orientation of the extremity of the boom will be determined to 20 arc seconds.

CHANGES FROM FY 1976 BUDGET ESTIMATES:

The decrease of $400 thousand in the transition quarter reflects adjustments resulting from the general Congress and reduction in NASA's R&D budget request for this three month period. Since the AEM base modules are under contract and work is in process, the impact of the funding constraint will be to delay the preliminary design of the AEM-B SAGE instrument module. This estimated delay of six weeks could effect the launch date of the mission.

BASIS OF FY 1977 ESTIMATES:

The FY 1977 funds will provide for the AEM-A instrument module which will be completed and integrated with the base module late in the fiscal year for a planned launch in early 1978. Fabrication of the AEM-B base module will be essentially complete during FY 1977 and the instrument module subsystem fabrication will be started.

Development of the AEM-C instruments and a boom attitude determination system will be initiated, and procurement action started for the base module.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1977 ESTIMATES

RESEARCH AND DEVELOPMENT PLAN FOR AERONAUTICS AND SPACE TECHNOLOGY PROGRAMS

Programs	Budget Plan					
		1976		Transition Quarter		1977
	1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
	(Thousands of Dollars)					
Aeronautical research and technology	166,400	175,350	175,350	46,800	43,800	189,100
Space research and technology	71,365	74,900	74,900	22,300	19,300	82,000
Total	237,765	250,250	250,250	69,100	63,100	271,100

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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1977 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Research and technology base....	83,472	85,100	85,425	23,800	21,400	89,700
Systems studies.....	2,884	3,000	3,096	700	700	3,000
Systems technology programs.....	31,022	46,550	43,170	15,800	12,300	60,800
Experimental programs.....	49,022	40,700	43,659	6,500	9,400	35,600
Total.....	166,400	175,350	175,350	46,800	43,800	189,100
Distribution of Program Amount by Installation:						
Johnson Space Center.....	100	280	350	70	225	575
Marshall Space Flight Center....	670	600	740	150	125	800
Goddard Space Flight Center.....	---	---	100	---	---	200
Jet Propulsion Laboratory.....	1,540	1,200	730	390	262	1,215
Wallops Flight Center.....	290	250	405	110	250	365
Ames Research Center.....	48,023	44,150	44,953	12,000	8,558	33,708
Flight Research Center.....	12,683	17,400	16,820	4,300	4,845	17,015
Langley Research Center.....	61,781	64,740	63,966	17,000	17,566	80,309
Lewis Research Center.....	39,511	43,990	44,737	12,000	11,431	52,403
Headquarters.....	1,802	2,740	2,549	780	538	2,510
Total.....	166,400	175,350	175,350	46,800	43,800	189,100

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY — AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Aeronautics program are to advance aeronautical technology to ensure safer, more economical, efficient and environmentally acceptable air transportation systems which are responsive to current and projected national needs; to maintain the strong competitive position of the United States in the international aviation marketplace; and to support the military in maintaining the superiority of the Nation's military aircraft.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

There were no changes from the FY 1976 budget estimate for the Aeronautical Research and Technology program as a whole. However, funding shifts did occur between individual programs within the Aeronautics program. These funding shifts reflect adjustments made to the program in response to unanticipated opportunities and changing program requirements which have developed since the budget estimates were provided, and to restructuring of elements in the Systems Technology and Experimental programs areas to accommodate the increased aircraft energy efficiency technology efforts. Explanations of significant funding changes are provided under each of the individual programs involved.

Transition Quarter Estimate:

The decrease of $3 million reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the transition quarter. The resulting funding decreases in individual programs were accommodated by deferring the purchase of some supplies and services until early FY 1977. Restructuring of elements in the Systems Technology and Experimental programs areas accommodate the increased aircraft energy efficiency technology efforts resulted in funding shifts between programs in these areas. Explanations of these funding shifts are provided under each of the individual programs involved.

BASIS OF FY 1977 ESTIMATES:

A strong research effort will be maintained in the disciplinary areas of materials, structures, propulsion, avionics, aerodynamics and human-vehicle interactions to provide advanced technology to meet the future needs of civil aviation. The FY 1977 program will continue to focus on developing the

technology to enable improved performance, reduced energy requirements, enhanced operating economy, reduced undesirable environmental effects such as noise and pollution, improved safety and reliability, and improved terminal area operation for all types of aircraft. These technology efforts are integrated with additional focused technology efforts to develop advanced long haul and short haul air transportation system concepts, including stationary-wing aircraft in the subsonic, supersonic and hypersonic speed regimes, as well as rotorcraft and hybrids.

The aeronautics research program has been refocussed to emphasize the development of technologies that will contribute to the achievement of a substantial reduction in aircraft energy requirements through increased efficiency. These aircraft energy efficiency technology efforts represent a multifaceted activity encompassing a broad spectrum of disciplines and focusing primarily on those technologies that will lead not only to more energy efficient derivatives and/or retrofits of current aircraft, but also to more energy efficient designs of future aircraft. These technology efforts represent the culmination of an intensive study involving other agencies plus the aircraft and airline industries, with the objective of identifying and defining principal areas deemed most crucial and requiring the greatest involvement by NASA while still promising the most probable payoff in increased aircraft efficiency. The resulting technology efforts are focused in five principal areas: Engine Component Improvement; Energy Efficient Engines; Laminar Flow Control; Energy Efficient Transport; and Composite Primary Aircraft Structures. Each of these elements has been defined in phases covering a span of 10 years, with only the primary phases being included in the FY 1977 budget estimate. Although the thrust of the technology in each of these areas is the development of energy efficient transports, it is recognized that in order to have the technology implemented in the civil air transportation system, other requirements must also be incorporated, such as environmental acceptability, safety, reasonable acquisition and maintenance, cost and passenger acceptance. Therefore, the efforts will address all aspects of air transport system efficiency, with fuel efficiency as a fundamental quantitative measure of success. The Composite Primary Aircraft Structures element, which is one of the Experimental Programs in the FY 1977 budget, includes the former Composite Primary Structures element of the Materials and Structures Systems Technology program. The Engine Component Improvement element and the Energy Efficient Engines element incorporate the former Advanced Energy Conservative Turbofan effort and are contained in the Propulsion Systems Technology program. The Laminar Flow Control element is located in the Aerodynamic Vehicle Systems Technology program. The Energy Efficient Transport element is contained in the Advanced Civil Aircraft Systems Technology program and incorporates the former Fuel Conservative Aircraft element of the same program, as well as active controls technology formerly contained within the Active Control Aircraft element of the Avionics Systems Technology program.

BASIS OF FUNDING REQUIREMENTS:

RESEARCH AND TECHNOLOGY BASE

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)					
Materials research and technology.....	6,637	6,200	6,450	1,700	1,600	6,500
Structures research and technology.....	6,755	6,250	6,700	1,800	1,500	6,700
Propulsion environmental impact minimization research and technology....	11,286	11,410	11,495	3,200	2,800	12,200
Propulsion components research and technology.....	9,179	9,050	9,500	2,700	2,500	10,000
Air breathing engine research and technology.....	7,608	8,150	7,558	2,000	1,800	7,800
Avionics research and technology.....	3,800	3,580	3,800	1,000	900	4,500
Fluid and flight dynamics research and technology.....	9,292	10,200	10,500	2,900	2,600	11,500
Low speed vehicle aerodynamics and flight dynamics research and technology.....	12,278	12,500	12,200	3,500	3,200	12,200
High speed vehicle aerodynamics and flight dynamics research and technology.....	8,541	8,830	8,700	2,500	2,300	8,900
Aircraft operations and safety research and technology.....	3,445	3,900	3,522	1,100	1,000	4,100
Aeronautical human,vehicle research and technology.....	4,651	5,030	5,000	1,400	1,200	5,300
Total	83,472	85,100	85,425	23,800	21,400	89,700
	Materials Research and Technology					
	6,637	6,200	6,450	1,700	1,600	6,500

OBJECTIVES AND STATUS:

This program is concerned with the development of advanced materials aimed at improving the safety, performance, longevity, and economy of civil and military aircraft. Emphasis is on high temperature engine materials, lightweight aircraft materials, and life prediction of these materials.

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CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

The FY 1976 increase of $250 thousand reflects higher than anticipated costs of services in support of the in-house materials research efforts.

Transition Quarter Estimate:

The decrease of $100 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the transition quarter. The decreased funding will delay until FY 1977 the award of several contracts in high temperature composite materials that are scheduled for renewal in the transition quarter.

BASIS OF FY 1977 ESTIMATES:

Basic materials studies on understanding the strengthening and failure mechanisms of alloys, composites, and ceramics will be continued in FY 1977. Research will also continue on means to improve the capabilities of high temperature materials for gas turbine blades, vanes, disks, and seals. Reducing the cost of manufacturing and processing will receive increased emphasis.

During FY 1977 the syntheses of new and improved polymers, composites and lightweight metals will emphasize the needs for safer, lightweight aircraft materials. Low temperature (70-150 degress Fahrenheit) curing structural adhesives with strength and lifetime comparable to state-of-the-art 350 degrees Fahrenheit curing adhesives will be studied. The foreign object impact resistance of boron/aluminum engine fan blades will continue to receive emphasis. Several high temperature polymers will be modified to improve their processability for composite fan blades.

In addition, a study of fatigue and fracture behavior of metals and composite materials will continue in FY 1977 to improve life prediction procedures and fracture control techniques for greater reliability and lower cost of both aircraft structures and propulsion systems.

Structures Research and Technology

1975	1976		Transition Quarter		1977
	Budget	Current	Budget	Current	Budget
Actual	Estimate	Estimate	Estimate	Estimate	Estimate
		(Thousands of Dollars)			
6,755	6,250	6,700	1,800	1,500	6,700

OBJECTIVES AND STATUS:

Structures technology for improving the performance, safety, durability, and economy of commercial, military, and general aviation aircraft is the objective of this program.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

The FY 1976 increase of $450 thousand reflects higher than anticipated costs of services in support of the in-house structures research efforts.

Transition Quarter Estimate:

The decrease of $300 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the transition quarter. The decreased funding will necessitate postponement until FY 1977 of a part of planned studies of improved concepts for crashworthy general aviation aircraft and of some analytical support for experimental programs in hypersonic structures and aeroelasticity.

BASIS OF FY 1977 ESTIMATES:

In the joint NASA/Federal Aviation Administration (FAA) aircraft crashworthiness program, the testing of general aviation aircraft will continue in FY 1977. High-wing Cessna aircraft will be supplied by the FAA. Investigations of crashworthy seats and fuselage modifications will be conducted. In the area of hypersonic aircraft structures, development of efficient concepts for high temperature flight environments will continue. More efficient computerized analysis and design methods will be developed and evaluated.

Improvements in analytical and test techniques in the areas of loads, aeroelasticity and structural dynamics will also be continued. These efforts will include analytical and experimental studies of unsteady aerodynamics for control surfaces; incorporation of aeroelastic loads prediction methods in the FLEXSTAB computer program; and flights of a Firebee II drone to measure loads and demonstrate flutter suppression techniques.

Analytical and experimental studies will be continued in FY 1977 to provide advanced techniques for predicting structural life and improving integrity and reliability. Increased emphasis will be given to the fatigue behavior of composite structures with particular attention to the effects of service environments and the development of concepts for damage tolerance.

In addition, studies to improve the understanding and prediction of the structural behavior of composites will continue in FY 1977. Improved theories and advanced materials will be explored and their suitability investigated in laboratory tests of composite components. Routine airline flight service evaluations of composite secondary structures on more than forty aircraft will continue. These secondary components include fairings, spoilers, rudders, and aft pylon skins. More than one million flight hours are expected to be accumulated by the end of FY 1977.

Propulsion Environmental Impact Minimization Research and Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
11,286	11,410	11,495	3,200	2,800	12,200

OBJECTIVES AND STATUS:

The propulsion environmental impact minimization research and technology program will lead to a reduction in aircraft propulsion system noise and exhaust pollution emissions, and will develop improved methods for prediction of the noise and pollution impact on the environment.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

The increase of $85 thousand represents adjustments and balancing of program effort between Propulsion Environmental Impact Minimization, Propulsion Components and Air Breathing Engine Systems to meet changing program needs.

Transition Quarter Estimate:

The decrease of $400 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the transition quarter. Experimental research on forward velocity noise effects initially planned for the transition quarter will be partially deferred into FY 1977 as a result of the reduction of funding for the transition quarter.

BASIS FOR FY 1977 ESTIMATES:

Propulsion noise reduction research will extend fundamental studies of generation, propagation, and suppression of noise from all major noise sources. Basic research emphasis will be on engine inlet and duct acoustic suppression techniques, impingement and scrubbing noise, wing shielding effects, processes of propagation and attenuation of noise by the atmosphere, and the effects of forward velocity on propagation and suppression. Large scale investigations to determine the effects of forward velocity on engines and/or airframe will utilize the unique capabilities of the Ames Research Center 40- by 80- foot wind tunnel. Applied research will emphasize internal core noise sources comprising combustors, turbines, struts, and stators. Investigation of promising exhaust nozzle noise suppressor concepts will be continued.

A follow-on contract for aircraft noise prediction will be signed that will build on prior efforts to incorporate all available state-of-the-art knowledge in aero-acoustics to produce computational techniques for the most accurate prediction yet developed of aircraft noise impact on terminal areas.

The exploration of concepts to reduce landing/take-off emissions from small aircraft gas turbine and turboprop engines will be completed, and further research on promising general aviation piston engine emission reduction concepts will be initiated. Efforts in larger gas turbine emission research will emphasize reductions in oxides of nitrogen pollutants emitted by engines during subsonic cruise operations, and will include explorations of variable-geometry combustor concepts based on prior fundamental research. The need for such reductions was indicated in the Climatic Impact Assessment Program (CIAP) report issued in 1975.

Propulsion Components Research and Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
9,179	9,050	9,500	2,700	2,500	10,000

OBJECTIVES AND STATUS:

The objectives of the aeronautical propulsion components research and technology program are to increase efficiency and operating range, improve specific fuel consumption and reduce the weight of the many interactive components making up aircraft engines and propulsion system installations. This program spans a

range of research investigations covering all components for large as well as small turbine engines, and includes fuels research.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

The current FY 1976 estimate reflects an increase of $450 thousand. The increase represents adjustments and balancing of program efforts between Propulsion Environmental Impact Minimization, Propulsion Components, and Air Breathing Engine Systems to meet changing program needs.

Transition Quarter Estimate:

The decrease of $200 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the transition quarter. The reduction of funding for the transition quarter will defer into FY 1977 part of the experimental research on seals, bearings, lubrication, and transmissions initially planned for the transition quarter.

BASIS OF FY 1977 ESTIMATES:

Propulsion aerodynamics research will provide empirical design data for a systematic matrix of supersonic inlets, and will generate analytical techniques to account for the effects of shock-wave-boundary layer interactions and boundary layer bleed. A three-dimensional viscous analysis of the flow in subsonic diffusers will be generated, and an investigation will be undertaken to determine the performance of promising two-dimensional nozzle concepts when integrated into aircraft configurations.

Fan and compressor research will define the practical limits of pressure ratio attainable in high performance compressors, consistent with minimum performance degradation due to erosion and wear. Improved analytical techniques will be applied to the design of these compressors as well as on high efficiency, high subsonic speed propellers and fans.

Combustion research will be conducted at gas temperatures of 4,000 degrees Fahrenheit and pressures of 40 atmospheres in practical combustor concepts. Turbine research will be concerned with high aerodynamic efficiency with minimum cooling air requirements at these temperatures and pressures. Detailed analytical and experimental studies will be performed to determine the synthesis and properties of jet fuel derived from shale and coal.

Mechanical components research will emphasize advanced reduction gearing and fundamentals of lubrication. Heat exchange research programs will be expanded to provide the technology for energy conservative, regenerative gas turbine engine cycles.

Air Breathing Engine Systems
Research and Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
7,608	8,150	7,558	2,000	1,800	7,800

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 the assessment of potential new system concepts.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

The current estimate is $592 thousand below the budget estimate as a result of adjustments and balancing of program effort between Propulsion Environmental Impact Minimization, Propulsion Components, and Air Breathing Engine Systems to meet changing program needs.

Transition Quarter Estimate:

The decrease of $200 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the transition quarter. Part of the advanced electronic controls research initially planned for the transition quarter will be deferred into FY 1977 as a result of this funding reduction.

BASIS FOR FY 1977 ESTIMATES:

In the area of propulsion systems dynamic behavior and control, the benefits of an on-line digital computerized control system concept will be evaluated for management of an advanced high performance turbofan engine over its entire flight envelope.

The joint NASA/United States Air Force full scale engine research program will continue through FY 1977. Experimental and analytical programs will place primary emphasis on an improved understanding of the phenomena of aeromechanical instability in fan/compressor systems.

The technology base, relative to the effects of circumferential and radial distortion patterns, flow angularity, dynamic pressure disturbances, and inlet temperature distortion on engine performance, will be strengthened during FY 1977 by completion of an experimental investigation on an advanced turbofan engine.

Hypersonic propulsion research during FY 1977 will involve supersonic combustor development, structural studies of flight-weight actively cooled propulsion systems, and integration of current supersonic combustion technology into a subscale scramjet module for performance testing in a wind tunnel at Mach numbers of 4 and 7.

The evaluation of advanced technology, fuel efficient, low pollution reciprocating engine cycles suitable for light aircraft application will be completed during FY 1977. This evaluation will include the Sterling and Diesel engines as well as the spark ignition engine with performance testing of the most promising fuel-efficient concept. A hydrogen enrichment system (previously developed for automotive use) will be flight tested during FY 1977 on a light twin engined reciprocating aircraft.

New engine design criteria and techniques for performance retention will be developed and demonstrated during FY 1977. Initial efforts will be to improve fan blade shapes, fan and turbine blade tip clearance techniques, engine gas path seals, and jet mixer nozzles. Advanced propeller/fan blade shapes in propeller-gear box-nacelle subassemblies will also be investigated during FY 1977 to determine integration effects at speeds to Mach 0.85.

Avionics Research and Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
3,800	3,580	3,800	1,000	900	4,500

OBJECTIVES AND STATUS:

The avionics research and technology program is focused on the design, development and testing of advanced avionic concepts for navigation, guidance, control, display, and communication subsystems for general aviation, vertical takeoff and landing (VTOL), and long and short haul aircraft.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

The increase of $220 thousand results from higher than anticipated increases in in-house support required for the vertical takeoff and landing avionics effort.

Transition Quarter Estimate:

The decrease of $100 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the transition quarter. The reduction in funding will result in reduced support in the highly reliable computer area. The deferred work will be supported by FY 1977 funds.

BASIS FOR FY 1977 ESTIMATES:

In the area of avionics research and technology, work on advanced avionics systems concepts will result in flight test of a fuel-optimal four-dimensional guidance system for conventional takeoff and landing aircraft. Related activities will provide an algorithm for flight path sequencing for mixed aircraft types by the end of FY 1977, along with development of digital control theory.

Efforts in innovative avionics will result in development of a computer program for antenna siting on general aviation aircraft during FY 1977. Feasibility testing of a low cost non-cooperative pilot warning system for uncontrolled terminal areas will begin.

Activities aimed at developing highly reliable fault-tolerant computer systems for civil aircraft are being conducted. Development of a transient-fault model and a software fault detection and correlation method will be completed by the end of FY 1977.

Automated VTOL avionics efforts are aimed at the synthesis of integrated avionics systems for reliable, cost-effective flight. Flight tests of automatic and manned flight display concepts will be completed in FY 1977, and flight tests of a multi-lateration landing guidance system will be initiated.

Fluid and Flight Dynamics
Research and Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
9,292	10,200	10,500	2,900	2,600	11,500

OBJECTIVES AND STATUS:

The objective of this program is to advance understanding of aerodynamic phenomena and improve predictive capability to permit increased performance optimization and ensure reduced adverse environmental effects of advanced aircraft during early design stages.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

The increase of $300 thousand supports expanded compliant wall and general aviation airfoil studies.

Transition Quarter Estimate:

The decrease of $300 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the transition quarter. The reduction of funding results in a postponement and stretch out in airframe noise, flight dynamics and unsteady aerodynamics research.

BASIS FOR FY 1977 ESTIMATES:

A major effort is directed toward providing capability to calculate complete flow fields and aerodynamic characteristics of complex aircraft and aerospacecraft. In FY 1977 continued emphasis will be placed on developing and verifying improved computer codes for the ILLIAC, STAR and CDC 7600 Computers. Improved turbulence models for introduction into the three-dimensional codes will be developed and the codes extended to handle more complex configurations. Definition studies of an optimized facility to process fluid dynamic equations will be started.

Efforts toward reducing adverse environmental effects are concentrated on airframe generated noise. In FY 1977 the effort will be continued to verify the scaling laws, investigate the noise contributed by individual airframe components, and develop methods for reducing such contributions. Also in FY 1977, a study of compliant walls as a means of achieving turbulent drag reduction applicable to more fuel efficient aircraft will be continued. The study will define optimum wall characteristics required to produce maximum drag reduction for practical durable surfaces.

As part of an expanded effort to provide analytical and design techniques for improved airfoils for all classes of aircraft, several new general aviation and rotating wing aircraft airfoils have been developed and tested. In FY 1977 the effort will be on extension of prediction and design capability to other classes of aircraft, and to handle flow regimes involving separated flow.

In addition, work will continue on methods to reduce transonic tunnel wall and model support interference, on improved flow diagnostic techniques, and on generalized aircraft stall-spin problems.

Low Speed Vehicle Aerodynamics and Flight Dynamics
Research and Technology

	1976		Transition Quarter		1977
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)			
12,278	12,500	12,200	3,500	3,200	12,200

OBJECTIVES AND STATUS:

The objective of this program is to develop and demonstrate advanced technology for four types of subsonic aircraft. Experimental and analytical studies are underway to improve the integrated aerodynamic performance, noise, stability, control, and flight dynamics of general aviation, advanced rotorcraft, advanced vertical take-off and landing (VTOL) aircraft, and advanced powered-lift short take-off and landing (STOL) aircraft.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

The reduction of $300 thousand results from transfer of some powered-lift research from the STOL aircraft area to conventional take-off transport types in the high speed vehicle aerodynamics area.

Transition Quarter Estimate:

The decrease of $300 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the transition quarter. The reduction of funding will result in the postponement and stretchout of some rotorcraft aerodynamic studies into FY 1977.

BASIS OF FY 1977 ESTIMATES:

In the area of general aviation, major effort will continue on stall-spin characteristics, including full-scale wind tunnel tests of various wing modifications indicated in small-scale tests to be effective in improving these characteristics, as well as flight tests to verify promising results of other tests of tail modifications. In other areas of research emphasis, a number of analytic, wind tunnel, and flight investigations will be undertaken on means of predicting and improving aircraft and propeller performance.

The rotorcraft research program will include continuation of the ground tests of promising rotor concepts such as the controllable-twist rotor with multicyclic control and advanced tilt rotors. Flight tests will define requirements for integrated displays and advanced control systems, to reduce pilot workload and improve efficiency and safety of operations in the terminal area and close to the ground, for both civil and military rotorcraft applications.

In the area of advanced VTOL aircraft, studies of improved ejectors and small-scale tests of vectored-thrust jet concepts will continue, and large-scale tests of a blown-flap concept will be initiated. Flight tests of advanced VTOL hover and touchdown manual control systems, utilizing the X-14 research aircraft, will be completed.

Powered-lift STOL aircraft technology studies will include large-scale tests of improved upper surface blown flap and augmentor-wing concepts; the potential of using the augmentor to improve cruise performance will be examined.

In FY 1977, further verification of handling qualities and certification criteria for powered-lift STOL aircraft will be achieved through simulation of the Air Force's YC-14 and YC-15 aircraft.

High Speed Vehicle Aerodynamics and Flight Dynamics
Research and Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
8,541	8,830	8,700	2,500	2,300	8,900

OBJECTIVES AND STATUS:

The objective of this program is to generate aerodynamic advancements needed to assure economic, safe, and reliable advanced high speed civil aircraft, and to establish technological superiority in future military systems.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

The reduction of $130 thousand is attributable primarily to early and successful completion of a remotely piloted vehicle stall/spin research activity and to transfer of compliant wall research to the Fluid and Flight Dynamics Research and Technology program.

Transition Quarter Estimate:

The decrease of $200 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the transition quarter. The reduction of funding results in a deferral into FY 1977 of a number of small research activities pertaining to oblique wings, high lift technology for transports, and hypersonic aerodynamics.

BASIS OF FY 1977 ESTIMATES:

In FY 1977 the development of complete and reliable methodology for aircraft design and aerodynamic predictive techniques for long haul transports will be advanced through evaluation of new conceptual designs and derivative cruise aircraft concepts. Wind tunnel models of subsonic, near sonic, and supersonic aircraft concepts will be tested. These efforts will incorporate component aerodynamic improvements such as the oblique wing, variable camber wings, augmented lift, and non-axisymmetric nozzles.

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Range and stability improvements will also be assessed and the most promising and practical concepts further incorporated into more detailed models for insights into interactions of component aerodynamic lifting and thrusting aerodynamic devices.

Basic maneuverability improvements to combat aircraft and missile configurations will be generated in FY 1977 through evaluation of non-linear aerodynamic phenomena associated with high-angle-of-attack/high-speed operation. Wind tunnel models and remotely piloted vehicles will be tested, and resultant data compared to theory and new analytical approaches. A differential maneuvering simulator will be employed, using data from model and aircraft test results, to analyze the benefit of incorporating the advanced aerodynamic concepts on total pilot/aircraft/missile capability.

Representative far-term hypersonic aircraft model configurations will be tested in laboratory facilities to establish a technology base for such potential future aircraft as a hypersonic transport, an air breathing launch vehicle, and advanced military aircraft.

Technical and test assistance provided to the Department of Defense in new military aircraft and missle development efforts will continue for both derivative configurations and new designs.

Aircraft Operations and Safety
Research and Technology

	1976		Transition Quarter		1977
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)			
3,445	3,900	3,522	1,100	1,000	4,100

OBJECTIVES AND STATUS:

The overall objective of the aircraft operations and safety research and technology program is to provide basic research and technology which can be used to solve a wide variety of aeronautical safety and safety-related operational problems. Three specific objectives provide focus for individual research efforts: (1) expansion of basic knowledge of atmospheric processes; (2) aircraft safety technology; and (3) aircraft system operational efficiency improvement.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

The FY 1976 decrease of $378 thousand reflects lower than anticipated costs of services in support of the in-house aircraft operations and safety efforts.

Transition Quarter Estimate:

The decrease of $100 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the transition quarter. The reduction of funding will result in deferring the acceleration of the rotor burst and protection program.

BASIS OF FY 1977 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 1977 research will continue the process of functionally defining and describing atmospheric phenomena in a way that will facilitate use of this information by designers, operators, and forecasters. Fine-scale characterization of wind shear and its genesis will be emphasized.

In the area of aircraft safety technology, research is focused on developing a technology base which can be used to reduce the chance of accident 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 1977, test and evaluation of fire resistant aircraft materials will continue. Systems tests of "safety" fuels will begin. Laser-Doppler systems will be employed in wind shear measurement and evaluated for in-flight turbulence detection. Operational wind shear environments will be measured with aircraft flight data recorders, and simulations of wind shear encounters will seek definition of operational hazard boundaries. Simulation of aircraft accidents will continue in support of the National Transportation Safety Board on an ad hoc basis. Rotor burst protection research will be accelerated to respond to industry needs.

The area of improving operational efficiencies of aircraft systems focuses on selectively boosting technology development which will permit increases in the service life and efficiencies of aircraft subsystems. During FY 1977 new tire tread materials will be evaluated on the landing loads track at the Langley Research Center and on the Federal Aviation Administration's B-727 leading to release for airline evaluation. Pilot-in-the-loop simulation of landing rollout will be refined to investigate hazardous control problems.

Aeronautical Human-Vehicle Research and Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
4,651	5,030	5,000	1,400	1,200	5,300

OBJECTIVES AND STATUS:

The objective of this program is to provide a research and technology base for solutions to the human problems impeding the growth or safety of air transportation. The program has four major areas of emphasis: human response to noise, ride quality, flight management, and simulation technology.

CHANGES FROM BUDGET ESTIMATES:

Transition Quarter Estimate:

The decrease of $200 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the transition quarter. This reduction of funding will result in deferral into FY 1977 of several contracts and grants in the flight management and human response to noise portions of the program.

BASIS OF FY 1977 ESTIMATES:

In the area of human response to noise research, studies will be conducted to determine the extent to which the results of Aircraft Noise Reduction Laboratory (ANRL) acoustic research can be generalized to residents of distant large city airport communities; to determine the effectiveness of noise reductions in various parts of the audible spectrum in reducing annoyance with aircraft noise; to examine the effect of background noise and low frequency noise on community reactions; and to investigate the effects of noise on speech production and perception in the aircraft cockpit environment. In addition, this program will be expanded to study the source, transmission path and receiver aspects of interior noise in general aviation.

In the area of ride quality, research will focus on efforts to examine the combined effects of noise, vibration and aircraft maneuvers (e.g., glide slopes and roll rates) on passenger acceptance of aircraft operations. Data will be refined as a basis for establishing criteria for passenger acceptance of future aircraft motion environments.

Flight management research efforts will continue evaluation, through part-task and full mission simulation, of control and display alternatives, flight procedures and crew roles for future aircraft systems. General research on the required cockpit configuration for the 1980's, information and decision making requirements for complex approaches, and the continued improvement of methods for assessing pilot performance and work-load will be pursued. In addition, research to define the information requirements for flight management of advanced transport system and Remotely Piloted Research Vehicle (RPRV) systems will continue.

In the area of flight simulation technology, emphasis will be placed on visual and vestibular system models and operational digital color display systems for high fidelity visual scene generation.

Systems Studies

	1976		Transition Quarter		1977
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)			
2,884	3,000	3,096	700	700	3,000

OBJECTIVES AND STATUS:

Systems studies are conducted primarily as a means of identifying the needs for technology advances and assessing their impact. The objectives of aeronautical systems studies are to determine the feasibility, technology requirements, costs, benefits and impacts of advanced civil and military aeronautical systems through mission, system and conceptual design studies. The studies will integrate the mutual effects of technology and a wide range of related factors.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

The increase of $96 thousand supports research efforts to study the impact of technology on operating economics of transport aircraft.

BASIS OF FY 1977 ESTIMATES:

Some 25-30 studies keyed to specific objectives in civil air transportation systems, future military aviation systems, and system analysis methodology and support are underway or being defined for FY 1976.

Studies of intercity transportation and lighter-than-air vehicles are being jointly funded with the Department of Transportation and the United States Navy, respectively. Comparisons of aeronautical fuel conservation options are being expedited to provide timely data for planning of aircraft energy efficiency technology efforts.

Based on needs and opportunities identified during long range planning activities and technology program evaluations, a variety of key study efforts will be conducted during FY 1977.

Studies of improved near-term and future civil air transportation systems, including both commercial and general aviation, will be carried out to evaluate concepts and tradeoffs, identify technology requirements and assess impacts and relationships to national needs.

Studies of future military aviation systems will also be conducted to evaluate concepts and tradeoffs and identify technology requirements, coordinating closely with the Department of Defense on identification of future military needs and missions.

In addition, methods for program assessment will be developed and implemented, and alternative overall program directions will be analyzed.

BASIS OF FUND REQUIREMENTS:

SYSTEMS TECHNOLOGY PROGRAMS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Materials and structures systems technology	3,300	8,100	4,200	4,400	1,600	6,400
Propulsion systems technology	500	2,500	4,400	1,200	1,700	18,000
Avionics systems technology	4,084	6,000	5,090	2,000	800	2,900
Aerodynamic vehicle systems technology	2,895	4,650	6,640	1,200	1,800	7,800
Aircraft operating systems technology	11,870	11,900	11,900	2,600	2,600	8,500
Aeronautical human-vehicle systems technology	---	200	200	100	100	500
Advanced civil aircraft systems technology	7,590	12,500	9,940	4,300	3,600	16,400
Military aircraft systems technology	783	700	800	---	100	300
Total	31,022	46,550	43,170	15,800	12,300	60,800

Materials and Structures Systems Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
3,300	8,100	4,200	4,400	1,600	6,400

OBJECTIVES AND STATUS:

The objective is to accelerate the transfer of advanced materials and structures technologies to application in design. This is accomplished by utilizing advanced materials and structures to fabricate airframe and engine components for laboratory evaluation and by development of essential computerized analysis and design methods.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 and Transition Quarter Estimates:

The Composite Primary Structures effort has been transferred from the Materials and Structures Systems Technology program to the Experimental Programs category as a result of an expansion of the effort as part of the aircraft energy efficiency technology efforts.

BASIS OF FY 1977 ESTIMATES:

The development of 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 FY 1977 effort will concentrate on the design of the IPAD system and the initiation of the coding of a first level IPAD system which is scheduled to be completed in FY 1981.

In the Materials for Advanced Turbine Engines program, the potential of new high-technology materials for use in advanced aircraft turbine engines will be demonstrated by scale up, 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. The contract effort being

initiated in FY 1976 will continue in FY 1977 through contracts with three engine producers involving: (1) low cost powdered metal processes for producing turbine discs, (2) a directional solidification process for better and cheaper turbine blades, and (3) abradable coatings to improve engine efficiency by eliminating hot gas leakage.

The Aeroelasticity of Turbofan Engines program was initiated in FY 1976 to improve capability for understanding and avoiding aeroelastic instability in turbine engine fan blades. This is an interdependent effort with the Aero Propulsion Laboratory of the Air Force. The activity is aimed at providing advanced design and test methods for coping with increasingly critical engine aeroelasticity problems by FY 1979. In FY 1977 the NASA effort will include completion and operation of a 20-inch diameter flutter rig, completion of computer programs for predicting unsteady aerodynamics on oscillating rotating airfoils, and the prediction of flutter involving strong shocks.

The Fire Resistant Materials Engineering program, initiated in FY 1976, is concerned with technology for fire resistant, low toxicity materials for use in aircraft construction and reducing the fire threat from fuel systems. In FY 1977 the synthesis of advanced fire resistant, low toxicity materials for use in aircraft interiors will be continued. Emphasis will be on testing of unattended areas, such as lavatories and cargo bays, using advanced materials. Base line studies will have been completed in FY 1976. Studies of increasing the fire resistance of fuselage and windows will be initiated. Studies Studies of anti-misting fuels will be continued. This program involves the major U.S. aircraft manufacturers and suppliers and is coordinated with the Federal Aviation Administration. The goal is to provide and demonstrate by FY 1980 the technology for maximum practical fire safety in air carrier aircraft.

Propulsion Systems Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
500	2,500	4,400	1,200	1,700	18,000

OBJECTIVES AND STATUS:

The objective of the Aeronautical Propulsion Systems Technology program is to achieve increased performance and efficiency of the complete propulsion system through integration of advanced propulsion components.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 and Transition Quarter Estimates:

Two elements of the aircraft energy efficiency technology efforts have been added to the Propulsion Systems Technology program. They include efforts on current engine component improvements and on advanced energy-efficient engines. The energy-efficient engines effort has absorbed both the advanced energy conservative turbofan effort and a part of the FY 1976 funding for the multi-stage axial flow compressor. The increases reflect the additional funding that was required to initiate these programs.

BASIS FOR FY 1977 ESTIMATES:

The Advanced Multi-Stage Axial Flow Compressor program began in FY 1975 with conceptual design study contracts awarded to two contractors. These contracts were completed in FY 1976. The goals of the studies were to achieve a design of a light weight, low cost, high performance axial flow compressor compatible with advanced energy conservative engines. A single contract will be awarded in FY 1977 for the final design, construction and test of an experimental axial flow compressor embodying the features cited above.

In FY 1975 in the Quiet, Clean General Aviation Turbofan program, NASA funded three parallel studies to assess the applicability of technology evolved for reducing large turbine engine emissions and noise to the class of turbine engines powering general aviation aircraft, primarily the business jets. A single contractor, selected in FY 1976, will design, build and test an experimental turbofan engine embodying concepts developed for the larger engines for reducing emissions and noise. Following contractor check-out of engine performance the engine will be delivered to the Lewis Research Center late in CY 1978 for extensive research testing.

New turbine engine combustor design concepts for subsonic transport aircraft will be explored in the Stratospheric Cruise Emission Reduction program. The objective will be to reduce the emission of nitrogen oxides during high altitude cruise operation by an order of magnitude below current practice. Ongoing research studies of combustion concepts have low NOx emission characteristics will be focused toward application to practical aircraft gas turbine operating conditions.

The Engine Component Improvement program is directed at developing more efficient engine components that could be used on new production of existing engine types. Components selected from detailed design and analysis studies completed in FY 1976 will be committed to development and testing in FY 1977. Examples of these components are active clearance control, mixers, and compliant seals. The improved components are expected to result in a 5 percent decrease in engine specific fuel consumption and be ready for use on engines produced in 1980 and beyond. In addition, tests of in-service engines will be conducted in FY 1977

in an attempt to determine the causes of engine performance deterioration with time. This program is one of the elements of the aircraft energy efficiency technology efforts.

The Energy Efficient Engines program is directed at establishing the technology base for achieving higher thermodynamic efficiences in future engine designs. Studies completed in FY 1976 show that incorporation of advanced components and subassemblies, resulting from previous NASA research, into an advanced turbofan propulsion system could result in a 10-15 percent reduction in cruise fuel consumption over currently available technology. In FY 1977 two contractors will be competitively selected to begin the design and experimental testing of compressor, combustor, and turbine components. By 1983 the advanced components will have been demonstrated through ground tests of an advanced experimental engine and will be ready for application to new engine designs. This program is one of the elements of the aircraft energy efficiency technology efforts.

Avionics Systems Technology

	1976		Transition Quarter		1977
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
	(Thousands of Dollars)				
4,084	6,000	5,090	2,000	800	2,900

OBJECTIVES AND STATUS:

This program applies the fundamental knowledge gained in the Research and Technology Base to develop and demonstrate the technical readiness and promote the transfer of advanced avionic systems to the aircraft industry through experimental testing and verification in a realistic environment.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 and Transition Quarter Estimates:

The funding reduction of $10 thousand and $1.2 million, respectively, in FY 1976 and transition quarter estimates is caused by the redirection and absorption of the Active Control Aircraft program into the energy efficient transport portion of the aircraft energy efficient technology effort. The energy efficient transport is carried in the budget under Advanced Civil Aircraft Systems Technology.

BASIS OF FY 1977 ESTIMATES:

The Digital 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. Currently in the Digital Fly-By-Wire program, experimental system hardware is being fabricated and checked out for the initial flight tests scheduled for April 1976. During FY 1977, the majority of the flight test evaluations will be conducted.

The General Aviation Advanced Avionics program is aimed at providing a totally integrated advanced, low cost avionics system to enhance the safety, reliability, and utility of future general aviation aircraft. In the area of advanced avionics for general aviation, studies are underway to assess the air traffic control and the electronic technology environments of the 1980's for application to the system definition. In FY 1977 preliminary specifications and a cost/benefit analysis will be completed as well as the development and flight evaluation of most of the critical subsystem components required for final design.

Aerodynamic Vehicle Systems Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
2,895	4,650	6,640	1,200	1,800	7,800

OBJECTIVES AND STATUS:

The broad objective is to evaluate selected advanced aerodynamic systems concepts for improving aircraft performance, efficiency, operating costs, safety, handling qualities, maneuverability, community acceptance, and other important aircraft characteristics through coordinated system technology studies, focused laboratory experiments, and flight validations.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 and Transition Quarter Estimates:

The increase of $1.99 million and $600 thousand, respectively, in FY 1976 and the transition quarter estimates provides for research in laminar flow control as part of the aircraft energy efficiency technology effort and for the much needed flight validation of airframe/propulsion systems interactions.

BASIS FOR FY 1977 ESTIMATES:

In the System Technology Studies program, preliminary design studies of advanced lift-fan and hingeless tilt rotor concepts for vertical take-off and landing aircraft applications, begun in FY 1976, will be completed in FY 1977.

In the Wake Vortex Minimization program, coordinated laboratory and flight investigations will continue in FY 1977 to develop and demonstrate aerodynamic methods to reduce the landing and take-off separation distance imposed by wake vortices generated by large jet transports on trailing aircraft. Results of ground facility and preliminary flight research during the past two years indicate that the goal of reducing the safe distance to two miles is feasible by utilizing several techniques for altering wing lift distribution and/or introducing turbulence by such means as flap and spoiler alterations. The effort in FY 1977 will be extended to include fundamental studies to determine aerodynamic design factors that influence the formation and destructive interference of multiple vortex systems, improved computational techniques which could be used to provide aircraft designs optimized for minimizing wake vortex effects, and selected flight validation tests of alleviation techniques.

In the Rotor Systems for Rotor Systems Research Aircraft program, a major activity will continue on advanced rotor systems to exploit the potential for substantially improved military and civil helicopters in the broad areas of performance, efficiency, noise, dynamics, and maintainability through integrated systems technology development and flight validation. Contractual predesign and systems design studies completed in FY 1976 on aero/acoustic, bearingless composite structure, and variable-geometry rotor concepts will serve as the basis to begin in FY 1977 the detailed design and fabrication of two full-scale advanced research rotor systems for thorough evaluation on the Rotor Systems Research Aircraft.

Impressive fuel savings, of the order of 20-40 percent, may be available through the use of laminar flow control on new aircraft designs. Previous efforts on the Air Force X-21 research aircraft demonstrated the possibility of flow laminarization, but did not answer practicality questions. The current Laminar Flow Control program (LFC) is directed at developing aerodynamic, materials, structures and systems technologies for demonstration of a practical, reliable, easily maintainable LFC system. In FY 1977 current efforts will be substantially augmented on advanced boundary layer computational methods, on acoustical environment effects on boundary layer stabilization with suction, and on surface materials and structural concepts for optimum suction systems. Major new analytical and experimental investigations will be undertaken in FY 1977 to develop advanced airfoils for LFC applications including wind tunnel tests of a swept wing section. This program is one of the elements of the aircraft energy efficiency technology efforts.

In FY 1977 in the Airframe/Propulsion Interactions program, flight research with F-15 aircraft will be conducted to obtain data specifically pertinent to a fundamental understanding of factors contributing to airframe/propulsion system interactions, especially inlet spillage and afterbody drag. The flight data

will be correlated with data from wind tunnel programs using sophisticated models of the aircraft having simulated propulsion systems, for the purpose of devising improved design prediction methods regarding airframe/propulsion system interactions in future aircraft developments.

Aircraft Operating Systems Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
11,870	11,900	11,900	2,600	2,600	8,500

OBJECTIVES AND STATUS:

The objective of this program is to develop technology for advanced airborne operating systems which optimize use of runways, terminal airspace, and the air traffic control system, while reducing noise to a minimum. It will provide proven airborne system concepts, flight procedures, and techniques for advanced aircraft which will support economic, service, ecological, and increased safety criteria.

BASIS OF FY 1977 ESTIMATES:

In the System Technology Studies program, efforts will include analysis of the operational compatability of future civil air transportation concepts; investigation of low cost avionics for small community microwave landing system (MLS) users; continued investigation of area navigation techniques at low altitudes; and analysis of the role for simulation in certification of all-digital avionic systems.

In the Terminal Configured Vehicle Systems program, a coordinated effort with the Federal Aviation Administration (FAA), a Boeing-737 aircraft will be used in development and demonstration of the capability to operate in a high density terminal area with MLS, flying a complete flight profile from area navigation transitioning to MLS, and completing an automatic landing and roll-out.

In the Short Take-Off and Landing (STOL) Operating Systems program, a related effort is being conducted for STOL aircraft under a joint agreement with FAA. Simulation and flight experiments will continue using a powered-lift augmentor wing jet STOL research aircraft and a Twin Otter to define methods by which STOL aircraft can be operated effectively and safely in future air traffic environments.

In the Vertical Take-Off and Landing (VTOL) Operating Systems program, flight experiments will be conducted as part of a joint effort with the Army in helicopters fitted with advanced digital avionics to provide a technology data base for VTOL aircraft to operate into confined areas without runways, using steep, circuitous, instrument approach paths, decelerating to zero speed while descending to the landing spot.

Aeronautical Human-Vehicle Systems Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
---	200	200	100	100	500

OBJECTIVES AND STATUS:

The objective of this program is to reduce the incidence of aviation incidents and accidents attributable to human error, develop technology and operational procedures that will insure optimum crew coordination in multipilot aircraft and implement an aviation safety reporting system.

BASIS OF FY 1977 ESTIMATES:

During FY 1977 the Approach and Landing Safety program will include full mission simulations to explore the potential of crew duty allocation approach procedures, and air traffic control procedures to decrease the possibility of human error. In addition, the Aviation Safety Reporting System will be in operation. This System, designed and implemented at the request of the Federal Aviation Administration, provides a means for pilots, controllers, and others in the National aviation system to report confidentially situations or conditions that they consider a threat to aviation safety.

Advanced Civil Aircraft Systems Technology

7,590	12,500	9,940	4,300	3,600	16,400

OBJECTIVES AND STATUS:

The objective is to provide an integrated technology base for transport vehicles in short-haul and long-haul categories, including the interactive effects of the various disciplines (propulsion, aerodynamics, structures, control, and the economic environment). An additional objective is to carry promising

technologies generated in the Research and Technology Base programs through ground systems tests and flight tests to the point where it is possible to establish the need for more specialized research.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 and Transition Quarter Estimates:

The reduction of $2.56 million and $700 thousand, respectively, in FY 1976 and the transition quarter estimates to the Advanced Civil Aircraft Systems Technology program reflects realignment of funding and programs in support of the aircraft energy efficiency technology efforts. Offsetting increases have been made to the Propulsion Systems Technology and the Aerodynamic Vehicle Systems Technology programs in an effort to accelerate technology in these areas which are critical to energy efficient aircraft.

BASIS OF FY 1977 ESTIMATES:

In the Systems Technology Studies program, studies for passenger and cargo civil transports are performed to quantify technical advances that improve aircraft efficiencies, noise emissions, and airport and airway capacity. Studies will include an assessment of the benefits of composite structures, advanced controls, noise and emission suppression, liquid hydrogen fueled and advanced lift systems could have on future transport systems.

In the YF-12 Flight Experiments program, NASA YF-12 aircraft are operated from subsonic to high supersonic cruise speeds to evaluate current analytical techniques, to provide the basis for improved design predictions, to carry structural and aerodynamic experiments in support of the Supersonic Cruise Aircraft Research Program (SCAR) and to validate advanced integrated inlet and airframe control systems.

In the Variable Cycle Engine (VCE) Components program, VCE components development will provide the technology base required for a low-noise, minimum pollution, economically feasible engine for a supersonic cruise aircraft, as well as for research in other flight regimes. Flow-field studies will be conducted in FY 1977 for optimum integration techniques. Common components, including a composite fan, high temperature liners, and low pollution combustor are being designed as part of the SCAR program and will be built in FY 1977 for wind tunnel tests. Unique VCE components such as lightweight fans, diverter valves, and duct-heaters will be studied for future experimental hardware investigations.

In the Hypersonic Research program, research activities in propulsion, structures and aerodynamics are to be augmented by the development of experiments which could be carried on a hypersonic research airplane. Studies are being conducted in a joint effort with the Air Force to define an X-24C hypersonic vehicle to provide the flight test capabilities required for Air Force and NASA experiment objectives. The X-24C would carry ground-based research results into flight to establish with sufficient scale and in actual

flight conditions the solutions to interactive propulsive, structural and aerodynamic problems, and to provide a test bed for advanced weapons systems. A joint USAF/NASA X-24C preliminary design study will be conducted in FY 1977, and will be the basis for a decision to proceed with the vehicle development and flight research program.

The Energy Efficient Transport program is directed at the evolutionary improvement of aerodynamic design and the development of active controls technology. In FY 1977, improved airfoil section technology will be applied to the design of higher aspect ratio wings with lower sweep. Critical problems of active controls to permit designs with reduced static stability margins will be addressed. These technologies will apply to new aircraft designs resulting in a fuel savings of the order of 15-20 percent. Some of the aerodynamic improvements could be incorporated in the designs of derivatives of currently produced aircraft. This program is one of the elements of the aircraft energy efficiency technology efforts.

Military Aircraft Systems Technology

1975	1976		Transition Quarter		1977
	Budget	Current	Budget	Current	Budget
Actual	Estimate	Estimate	Estimate	Estimate	Estimate
		(Thousands of Dollars)			
783	700	800	---	100	300

OBJECTIVES AND STATUS:

Aircraft and missile technologies especially applicable to military needs are researched and validated through wind tunnel and flight tests creating engineering and design data capabilities. These programs are implemented through cooperative and/or joint Department of Defense/NASA technical efforts.

CHANGES FROM BUDGET ESTIMATE:

FY 1976 and Transition Quarter Estimates:

The increase of $100 thousand in FY 1976 and in the transition quarter estimates reflects additional safety maintenance on the F-111 and an augmentation of the wind tunnel effort.

BASIS OF FY 1977 ESTIMATES:

The Joint United States Air Force (USAF)/NASA Transonic Aircraft Technology (TACT) program provides flight test validation of recent advances in supercritical wing technology from flight and wind tunnel

tests, data correlation, and adequacy of predicting full-scale results from small-scale wind tunnel model tests.

To date, flight testing has explored stability and control, flutter, buffet, and other aerodynamic parameters. Initial performance data shows that all anticipated improvements have either been met or exceeded.

In FY 1977, the wind tunnel testing of the high strength and buffet models, the wind tunnel test data reduction, and its correlation with flight test data by the USAF and NASA will be completed, resulting in a Correlation Data Manual.

BASIS OF FUND REQUIREMENTS:

Experimental Programs

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Composite primary aircraft structures	---	---	3,995	---	2,800	16,000
Quiet, clean, short haul experimental engine	10,000	10,000	10,000	2,000	2,000	3,300
Quiet propulsive lift technology	8,000	11,900	11,900	400	400	1,700
Supersonic cruise aircraft research	8,994	8,900	8,864	2,000	2,000	8,000
Tilt rotor research aircraft	11,300	1,900	1,900	300	300	800
Rotor systems research aircraft	8,100	3,100	2,100	---	100	300
Highly maneuverable aircraft technology	1,643	4,900	4,900	1,800	1,800	5,500
Refan	985	---	---	---	---	---
Total	49,022	40,700	43,659	6,500	9,400	35,600
Composite Primary Aircraft Structures						
	---	---	3,995	---	2,800	16,000

OBJECTIVES AND STATUS:

The objective of the composite primary aircraft structures effort is to develop the technology needed to assure early use of advanced composite materials in primary structures of future transport aircraft. The long term reliability and maintainability of composites must be proven before composites will be extensively used.

A contract was signed with Lockheed in June 1975 for the development, design, fabrication, test and certification, and flight evaluation of two L-1011 vertical tails. Similar contracts will be initiated in FY 1976 for a wing and fuselage. Activities are underway to provide technology demonstration/proof-of-concept for use of these materials.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 and Transition Quarter Estimates:

The composite primary aircraft structures efforts were previously carried under the Materials and Structures Systems Technology budget category. As a part of the aircraft energy efficiency technology efforts, the scope of this effort was broadened and the efforts were incorporated under the Experimental Programs budget category.

BASIS OF FY 1977 ESTIMATES:

These activities will provide a tail, a wing, and a fuselage segment to be tested on existing commercially operated aircraft. The contract for the tail, which was awarded in FY 1975, and the contracts for the wing and fuselage segment, which will begin in FY 1976, will run through FY 1977 and beyond. These contracts include development, design, test, Federal Aviation Agency certification, and installation of components on scheduled airliners, replacing standard metal components, followed by five-year flight service evaluation phases. The weight savings of composites translate into fuel savings of the order of 10-15 percent. Moderate use of composites would be possible on aircraft introduced into service as early as 1985. This program is one of the elements of the aircraft energy efficiency technology efforts.

Quiet, Clean, Short Haul Experimental Engine (QCSEE)

	1976		Transition Quarter		1977
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)			
10,000	10,000	10,000	2,000	2,000	3,300

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

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propulsion systems, suitable for "under-the-wing" and "over-the-wing" externally blown-flap powered-lift aircraft installations.

Designs of both propulsion systems were completed and approved following critical design reviews conducted in January and July 1975. The contractor, the General Electric Company, is currently proceeding with fabrication of component hardware and will complete assembly of the "under-the-wing" propulsion system by June 1976. This propulsion system will be placed on test at the contractor's facility during the transition period.

BASIS FOR FY 1977 ESTIMATES:

The assembly of the "over-the-wing" propulsion system will be completed early in FY 1977 and also placed on test at the contractor's facility. Testing will continue throughout FY 1977 to demonstrate structural integrity and capability to meet performance, noise and pollution goals. The "under-the-wing" propulsion system tests will be completed and the system delivered to NASA by the end of the fiscal year. Total program duration will be approximately 56 months including engineering support for tests at NASA for a period of about 12 months after delivery of the first propulsion system.

Quiet Propulsive Lift Technology

	1976		Transition Quarter		1977
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)			
8,000	11,900	11,900	400	400	1,700

OBJECTIVES AND STATUS:

To generate and verify through ground-based and flight research a technology data base for design and certification criteria for efficient, quiet, propulsive lift, short,haul transports. Propulsive lift technology is a key to airport congestion relief, community noise reduction, and efficiency improvement for civil short-haul transports and military tactical airlift. Flight research includes experiments in the areas of aerodynamics, handling qualities, noise, flight control systems, information displays, propulsion systems and operations.

Participation in the United States Air Force YC-15 Advanced Medium Short Take-Off and Landing (STOL) Transport flight test evaluation began in CY 1975. The Quiet Short-Haul Research Aircraft is progressing on schedule with the award of the hardware contract anticipated by February 1976.

BASIS OF FY 1977 ESTIMATES:

Participation in the Air Force Advanced Medium STOL Transport (AMST) prototype program involves NASA utilizing both the Boeing YC-14 and McDonnel Douglas YC-15 aircraft to accomplish part of the propulsive-lift technology program objectives. In FY 1976 and FY 1977, NASA, as a member of the AMST Joint Test Team, will participate in the USAF flight evaluation of the AMST's and conduct special on-board research experiments.

An existing Buffalo aircraft will be modified in FY 1977 into a Quiet Short-Haul Research Aircraft with a hybrid upper-surface blowing, advanced propulsive-lift configuration to obtain stability, control, aerodynamic performance, noise footprint, and handling qualities flight research data.

Supersonic Cruise Aircraft Research

	1976		Transition Quarter		1977
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
	(Thousands of Dollars)				
8,994	8,900	8,864	2,000	2,000	8,000

OBJECTIVES AND STATUS:

To provide the focused technology base for future civil and military supersonic cruise aircraft, and to provide data to assess the environmental and economic impacts of aircraft of this class. These objectives constitute the framework within which an integrated program in the key technology areas of propulsion, structures, and aerodynamics can be combined to assess environmental and economic impacts for future decisions relative to desirability for the development of aircraft of this class.

Recent major progress in noise relief from coannular nozzles offer the prospect of a supersonic cruise aircraft meeting Federal Aviation Agency/FAR 36 noise goals.

BASIS OF FY 1977 ESTIMATES:

Promising design concepts for supersonic transport propulsion systems will be assessed for performance, noise, and emissions impact. With completion of tests of a duct-heating turbofan noise suppressor nozzle, emphasis shifts in FY 1977 to the effects of forward velocity and coannular suppression on the acoustic performance of nozzles. Ultra-low emission reduction studies will be applied to a duct heating augmentor.

Fatigue, fracture, and flutter characteristics under the severe environment of supersonic flight, must be addressed for the primary and secondary aircraft structures. A fuel tank sealants flight test program on the YF-12 will be completed in FY 1977. Composite resin and metal matrix panels fabricated and tested for fatigue characteristics will be flight tested on the YF-12 in FY 1977. Flutter model studies will be extended to assess active control systems for flutter suppression.

Major improvements in supersonic aerodynamic cruise efficiency are expected from wind tunnel test investigations. The combination of advanced theory, testing, and propulsion integration studies are expected to provide a 30-percent improvement in lift-to-drag ratio. The problems of control at very high Mach numbers will continue to be studied with YF-12 flight testing of a new longitudinal cooperative digital computer control system.

Tilt Rotor Research Aircraft

	1976		Transition Quarter		1977
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)			
11,300	1,900	1,900	300	300	800

OBJECTIVES AND STATUS:

The objective of this joint NASA/Army program is to perform proof-of-concept and advanced flight research investigations utilizing two tilt rotor research aircraft. A primary objective of this program is to evaluate the potential benefits of applying tilt rotor technology to various civil and military missions.

The Tilt Rotor Research Aircraft Program was initiated in FY 1973. Currently airframes for both aircraft are in the final assembly phase and rollout of the two aircraft will take place in FY 1976.

BASIS OF FY 1977 ESTIMATES:

The FY 1977 program activity will involve the contractor's flight substantiation beginning early in the fiscal year. In mid-FY 1977 the NASA/Army flight research program will begin. The government flight research program will involve approximately 200 hours of flight operation and will continue into FY 1979.

Rotor Systems Research Aircraft

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
8,100	3,100	2,100	---	100	300

OBJECTIVES AND STATUS:

The objective of this joint NASA/Army program is to develop two versatile research vehicles to allow testing of a variety of new rotor concepts in the real maneuvering flight environment that cannot be accurately simulated in ground-based facilities. In addition, the special research measurement systems incorporated in these vehicles will allow verification and further refinement of methods for analysis and design of advanced helicopter rotor systems.

The Rotor Systems Research Aircraft (RSRA) program was initiated in FY 1973 and has progressed to the stage of aircraft fabrication and assembly in mid-FY 1976.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 and Transition Quarter Estimates:

Funding on the RSRA program was accelerated by one million dollars in FY 1975 to cover revised contractual requirements. The total estimated cost to completion had been held unchanged and the difference reflected in the revised FY 1976 and the Transition Quarter estimates reflects the compensating adjustment to that action.

BASIS OF FY 1977 ESTIMATES:

Following aircraft ground tests, contractor flight tests will be conducted throughout FY 1977. The contractor flight substantiation program will include operation of the RSRA vehicles in the pure helicopter mode. Delivery of the vehicles is scheduled for the first quarter of FY 1978.

Highly Maneuverable Aircraft Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
1,643	4,900	4,900	1,800	1,800	5,500

OBJECTIVE AND STATUS:

The objective of this joint program with the Air Force 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 vehicles. The program will provide two unmanned, subscale, remotely piloted low cost flight research vehicles which will be extensively flight tested.

Design feasibility studies were completed in August 1973 and follow-on conceptual design studies were completed in November 1974. After a competitive procurement, a contract for the final design and fabrication of the vehicles was awarded in August 1975.

BASIS FOR FY 1977 ESTIMATES:

The Preliminary Design Review is scheduled for April 1976 and the Critical Design Review for October 1976. Fabrication and vehicle assembly will take place during FY 1977. The vehicles, scheduled for delivery in early FY 1978, will be flight tested at NASA's Flight Research Center.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1977 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Research and technology base....	61,090	61,300	61,075	18,500	15,700	62,100
System studies.....	1,600	1,600	1,825	400	400	1,600
Systems technology programs.....	1,675	2,200	2,200	800	600	3,100
Experimental programs.....	2,000	3,700	3,700	1,100	1,100	6,900
Low cost systems program.....	5,000	6,100	6,100	1,500	1,500	8,300
Total.....	71,365	74,900	74,900	22,300	19,300	82,000
Distribution of Program Amount by Installation:						
Johnson Space Center.....	171	150	294	---	65	1,410
Kennedy Space Center.....	---	50	50	---	30	---
Marshall Space Center.....	1,925	2,630	2,365	700	732	2,389
Goddard Space Flight Center.....	5,358	5,470	5,663	1,200	1,217	8,162
Jet Propulsion Laboratory.....	17,121	15,820	17,305	4,900	4,518	17,927
Wallops Flight Center.....	55	50	55	---	15	55
Ames Research Center.....	9,024	8,520	8,294	2,600	2,106	8,890
Flight Research Center.....	905	950	950	300	---	---
Langley Research Center.....	14,936	18,320	17,709	5,900	4,885	19,685
Lewis Research Center.....	19,506	20,380	19,005	6,000	5,155	20,493
Headquarters.....	2,364	2,560	3,210	700	577	2,989
Total.....	71,365	74,900	74,900	22,300	19,300	82,000

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The objectives of the Space Research and Technology program are to provide a technology base which will adequately support current and future space activities, and to implement approaches for further reducing the costs of these future space activities through standardization.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

There were no changes from the FY 1976 budget estimate for the Space Research and Technology program as a whole. However, funding shifts did occur between individual programs within the Space Research and Technology program. These funding shifts reflect adjustments made to the program in response to unanticipated opportunities and changing program requirements which have developed since the budget estimates were provided. Explanations of significant funding changes are provided under each of the individual programs involved.

Transition Quarter Estimate:

The decrease of $3 million reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the Transition Quarter. The resulting funding decreases in individual programs were accommodated by postponing the purchase of some supplies and services until early FY 1977.

BASIS OF FY 1977 ESTIMATES:

A strong research effort will be maintained in the disciplinary areas of materials, structures, fundamental electronics, guidance and control, information systems, chemical and electric propulsions, energy systems and aerothermodynamics to meet the needs of current and future space activities. System Studies will be pursued to investigate future space mission alternatives and to identify and evaluate the technology requirements of future missions. Systems Technology efforts will continue toward extending the temperature limits for composite materials to allow their use on advanced space transportation systems, and toward providing a

"no-moving-part" data storage system for aerospace vehicles. In FY 1977 increased Systems Technology emphasis will be given to the areas of multipurpose, user-oriented software technology, and to the demonstration of the readiness by FY 1980 of an advanced planetary orbiter spacecraft propulsion system utilizing high performance space storable fluorine-hydrazine propellants. The thrust of the software activity will be to develop generalized compiler systems capable of translating user needs into a standard higher order language, and thereby reduce future software development costs. Increased activity in the Space Technology payloads area is aimed at defining a series of flight experiments to be flown on the Space Shuttle during the early 1980's. In the Low Cost Systems area, the FY 1977 emphasis will continue to be on the development and upgrading of various standard spacecraft components.

BASIS OF FUND REQUIREMENTS:

Research and Technology Base

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Materials research and technology	9,179	8,900	8,675	2,700	2,300	8,700
Structures research and technology	5,424	5,420	5,355	1,600	1,300	5,500
Fundamental electronics research and technology	5,684	5,300	5,045	1,600	1,300	5,000
Guidance and control research and technology	3,106	3,400	3,290	1,000	800	3,500
Information systems research and technology	4,781	5,190	5,025	1,600	1,400	5,200
Chemical propulsion research and technology	7,506	8,290	8,250	2,600	2,200	8,300
Electrical propulsion research and technology	4,410	4,200	4,700	1,200	1,100	5,200
Space energy systems research and technology	8,170	7,290	7,810	2,200	1,800	7,800
Nuclear energy research and technology	2,188	2,200	2,025	700	600	2,000

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
High power lasers and energetics research and technology	4,965	5,410	5,200	1,600	1,400	5,200
Entry research and technology	5,677	5,700	5,700	1,700	1,500	5,700
Total	61,090	61,300	61,075	18,500	15,700	62,100
			Materials Research and Technology			
	9,179	8,900	8,675	2,700	2,300	8,700

OBJECTIVES AND STATUS:

The objective of this program is to provide advanced materials technology aimed at more efficient, lower cost spacecraft structures, thermal protection systems, and propulsion and power systems for future Earth orbiting and planetary vehicles.

CHANGES FROM BUDGET ESTIMATE:

FY 1976 Estimate:

The FY 1976 decrease of $225 thousand reflects lower than anticipated costs of services in support of the in-house materials research efforts.

Transition Quarter Estimate:

The decrease of $400 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the Transition Quarter. The decreased funding will postpone several grants and contracts in each area of materials science (electronic materials and superconductivity) and thermal protection systems and planetary probes.

BASIS OF FY 1977 ESTIMATES:

Basic materials research studies will continue to emphasize the mechanisms corrosion in light alloys, friction and wear in moving parts, strengthening in composites, and oxidation in high temperature materials. This understanding will serve as a guide to improve materials for advanced spacecraft.

During FY 1977 work in advanced electronic materials will address basic questions on the properties and limitations of very thin metal oxide semiconductor structures and will concentrate on basic research to identify efficiency limitations of gallium arsenide junction solar cells.

Advanced materials and manufacturing processes during FY 1977 will be studied for their application as long life space structures and lubricants and seals. Particular emphasis will be placed on composites for spacecraft structures and tankage. Metal matrix composites, primarily boron-aluminum, will be considered where service temperatures above 600°F or other considerations limit the use of organic matrices. Exploratory studies will consider boron-titanium for temperatures up to 1000°F.

The development of advanced thermal control techniques for the protection of spacecraft will be conducted in FY 1977. Particular emphasis will be placed on heat pipe cooling techniques and thermal control surfaces with low absorptance. Technology to improve thermal control systems for advanced Earth orbital spacecraft and planetary probes will be conducted in FY 1977 and the heat shield requirements for outer planetary probes will be assessed.

Structures Research and Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
5,424	5,420	5,355	1,600	1,300	5,500

OBJECTIVES AND STATUS:

This program provides advanced structures technology to meet the needs of future space systems. Emphasis is being placed on critical research and technology study efforts to provide improved capability to design future large space structures. These efforts focus on key areas such as techniques to achieve light-weight, durable structures and methods to increase the operational life and decrease the cost.

CHANGES FROM BUDGET ESTIMATE:

FY 1976 Estimate:

The FY 1976 decrease of $65 thousand reflects lower than anticipated costs of services in support of the in-house structures research efforts.

Transition Quarter Estimate:

The decrease of $300 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the Transition Quarter. The reduction of funding results in the deferral into FY 1977 of some research and technology efforts related to large space erectable structures, high temperature structures and structural responses to payload dynamics in space.

BASIS OF FY 1977 ESTIMATES:

In the area of advanced space structures, research and technology efforts will include the examination of new concepts for large erectable space structures needed for orbital antennas, solar arrays, and platforms. The concepts will include large antennas (100-meter diameter) which could be packaged as a single payload and deployed in orbit, and much larger structures which would require space fabrication and assembly. Advanced design techniques for lightweight composite structures will continue to be investigated.

Development of advanced design methods will continue in FY 1977 with primary emphasis on high temperature structures for future Earth to orbit transportation systems, and on improved wind tunnel testing techniques for these structures. Evaluation tests of Shuttle thermal protection structures will be conducted as necessary to support Shuttle development. Improvements for the NASA Structural Analysis (NASTRAN) program will also continue, and improved fracture control methods will be studied.

Space vehicle dynamics technology activities will include improved techniques for predicting payload acoustic and vibration environments and payload response, as well as supporting studies for the current Shuttle design. Effort on payload dynamics in FY 1977 will encompass improved methods for prediction and minimization of structural response, criteria for analysis and test correlation, improved techniques for upgrading analytical models based on test data, and participation in the preparation of a specific technology payload general test specification. The Shuttle support studies will involve methods for predicting aeroelastic effects and wind tunnel tests to help define pre-launch ground wind loads.

Fundamental Electronics Research and Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
5,684	5,300	5,045	1,600	1,300	5,000

OBJECTIVES AND STATUS:

Research and technology activities in fundamental electronics provide advanced high resolution sensors and detectors for data acquisition, electronic components for on-board information processing and data storage, and long-life circuit arrays for the synthesis of reliable, low-cost electronic systems.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

The current FY 1976 estimate is $255 thousand below the budget estimate. Planned efforts to develop liquid-crystal displays were terminated because of technical problems and successful development of an alternate approach by the Department of Defense.

Transition Quarter Estimate:

The decrease of $300 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the Transition Quarter. As a result, the development of techniques for laser remote sensing of oceanic parameters will be deferred until FY 1977.

BASIS OF FY 1977 ESTIMATES:

New technologies are being investigated to improve the resolution, sensitivity, and spectral range of active and passive remote sensing systems. In FY 1977, hydrographic lidar systems to measure oceanic salinity, temperature profiles, and turbidity will be developed. High resolution astronomical sensors and a planetary TV camera based on intensified charge-coupled device technology will be tested. Passive radar techniques will be developed for stratospheric remote gas/pollutant detection and measurement.

Electronic devices to improve system performance and reduce costs are being developed for aerospace applications. Improved room temperature infrared detectors will be developed. Solid-state charge transfer devices for analog signal processing will be demonstrated. Fabrication of a low error rate fiber optics data link for spacecraft application will be evaluated.

Large scale integrated electronic circuit arrays will be developed to provide increased function density, reduced cost, and improved performance and reliability. Studies of basic failure mechanisms will result in standardized devices for testing circuit reliability. Techniques for mask making, using computer-controlled electron-beam lithography, will be investigated and automated microcircuit processing equipment will be evaluated for "hands-off" fabrication.

Guidance and Control Research and Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
3,106	3,400	3,290	1,000	800	3,500

OBJECTIVES AND STATUS:

The purpose of this program is to develop components and techniques which will lower the life cycle costs of spacecraft attitude control systems, provide precise pointing of experiments, improve the accuracy of space navigation, and permit autonomous operation of spacecraft, robot vehicles and experiments in space.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

The reduction of FY 1976 funding reflects savings realized by performing work on the magnetic bearing reaction wheel speed controller as an in-house effort and discontinuing plans initiating effort on the control of flexible spacecraft.

Transition Quarter Estimate:

The decrease of $200 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the Transition Quarter. As a result, tests of a redundant laser gyro navigation system will be postponed until FY 1977.

BASIS OF 1977 ESTIMATES:

Guidance and control research centers on new concepts and components which promise reduced costs and increased mission capability. Development of long life attitude control system technology in FY 1977 will focus on completion of a solid state star tracker, test of a single axis magnetic bearing reaction wheel, and design of a fluid bearing gyro. Ground testing of a video inertial pointing system for infrared telescopes will be completed and a magnetic suspension device for high accuracy pointing of space experiments will be evaluated.

Advanced navigation techniques are being developed to reduce costs and increase the scientific return from missions to outer planets. During FY 1977, optimized maneuver strategies will be derived for planetary orbiters and multiple planet rendezvous. Final design of an autonomous on-board navigation system will be completed and development of a breadboard system will be initiated.

A robot demonstration vehicle will be completed during FY 1977 and tethered operations will be evaluated. Development of a radio control link and dual-manipulators will be initiated as precursors to semiautonomous operation in an outdoor environment. University studies of automated problem solving systems and scene interpretation techniques will be continued in FY 1977.

Information Systems Research and Technology

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
4,781	5,190	5,025	1,600	1,400	5,200

OBJECTIVES AND STATUS:

The objective of the space information systems program is to provide, through research, design, and experimental tests, the components and techniques needed for the processing, transmission and reduction of data from planetary and earth orbiting missions and data transfer satellites of the future.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

The decrease of $165 thousand resulted from termination of an activity to evaluate the use of multiple computers as an approach to long life operating systems because the resulting system complexity was found to negate gains in operating life.

Transition Quarter Estimate:

The decrease of $200 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the Transition Quarter. Research on materials for holographic memory systems will be deferred three months to accommodate the reduction.

BASIS OF FY 1977 ESTIMATES:

Testing of a modular data system breadboard, which performs control, measurement, and processing functions in a single architectural concept, will be completed. A first generation optical computer will be operated to explore its potential for real time parallel video processing. The development and evaluation of new optical holographic storage materials with densities of 10^8 to 10^{10} bits per square inch will be pursued.

The microwave data transfer efforts are aimed at the design of reliable spacecraft communications systems and components for multi-mission use. In FY 1977 microminiature components for digital radio systems will be constructed and tested. Development of millimeter wave (40 Gigahertz) high power amplifiers will be initiated. Research on medium power solid state Ku-band transmitters to obtain doubled life time (from 2 to 4 years) and efficiency (from 15 to 30 percent) will also continue.

The high rate data transfer and tracking activity is focused on the development of laser technology. A long life 300 megabit per second space qualified carbon dioxide laser transceiver engineering model will be evaluated during FY 1977. New modulation techniques to increase the capacity to 500 megabits per second will be investigated. A neodymium laser system will be assembled and tested to demonstrate a 2 centimeter tracking accuracy.

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Chemical Propulsion Research and Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
7,506	8,290	8,250	2,600	2,200	8,300

OBJECTIVES AND STATUS:

The objectives of this program are to advance the technology of conventional high thrust chemical propulsion systems to meet future mission requirements at reduced cost, and to explore promising advanced propulsion concepts that offer much higher specific impulse, as well as high thrust compared to the conventional chemical systems.

CHANGES FROM BUDGET ESTIMATES:

Transition Quarter Estimate:

The decrease of $400 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the Transition Quarter. The reduction of funding will result in the deferral until FY 1977 of some reusable chemical propulsion component research on pumps, thrust chambers and reusable insulation and of some solid propulsion research on long term propellant storability and high performance, light weight motors.

BASIS OF FY 1977 ESTIMATES:

The high performance,reusable chemical propulsion program will provide the technology for future low cost space transportation systems including small orbital transfer vehicles, and advanced Earth-to-orbit vehicles. The primary focus of this work is on small oxygen-hydrogen propulsion systems designed for reusable space vehicles that will operate from the Shuttle low Earth orbit to higher orbits and beyond. In FY 1977, component technology will continue on pumps, thrust chambers, high expansion ration nozzles, reusable insulation and auxiliary thrusters designed for reusability leading to a minimum 20-mission vehicle life.

The long life space storable propulsion technology program is designed to meet the requirements of the more demanding unmanned planetary missions of the future. The work is directed toward component technology for a fluorine-hydrazine propulsion system that would provide a 25 percent increase in performance over

current state-of-the-art systems and would be designed for a minimum five-year lifetime. In FY 1977, the component efforts will concentrate on flight weight designs, that will be procured for assembly into a complete propulsion system as part of the Space Propulsion and Power Systems Technology program.

In low cost solid propulsion, the technology program is directed toward improving performance, reducing component weights and developing new capabilities to promote broader use of these inherently low cost systems in NASA missions. During FY 1977, work will continue in the areas of heat sterilizable propellants, long term propellant storability, restartable motors, and high performance, lightweight motors. An advanced solid motor incorporating lightweight components and a higher performance propellant will be tested under simulated altitude conditions. Many of these features will be applicable to an improved version of the interim upper stage (IUS) for the Shuttle.

The major emphasis in advanced chemical propulsion concepts is on atomic and metallic hydrogen, and excited state helium. Experimental work will continue toward extending the storage time of atomic hydrogen by means of high strength magnetic fields, and testing of high pressure devices designed to exert megabar pressures on hydrogen samples will be initiated leading towards the production and storage of metallic hydrogen. Theoretical studies of determining means of storing excited state helium species in a solid helium matrix will continue.

Basic research will be continued to deepen the understanding of the chemical and physical processes that occur in rocket propulsion systems. Work in these areas in FY 1977 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: and behavior of fluids in a zero gravity environment.

Electrical Propulsion Research and Technology

	1976		Transition Quarter		1977
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)			
4,410	4,200	4,700	1,200	1,100	5,200

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 for advanced capabilities in near-Earth and planetary/interplanetary applications.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

The FY 1976 increase of $500 thousand reflects higher than anticipated costs of services in support of the in-house electrical propulsion research efforts.

Transition Quarter Estimate:

The decrease of $100 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the Transition Quarter. The reduction of funding will result in deferring until FY 1977 the initiation of testing a number of ion engines in an array configuration to understand interactions.

BASIS OF FY 1977 ESTIMATES:

In the area of auxiliary electric propulsion, a 15,000-hour, 460-cycle endurance test of an 8-centimeter diameter laboratory model, 1 millipound (150 watts) mercury ion engine was successfully completed in FY 1976. Cyclic endurance testing of an 8-centimeter engineering model ion engine with a thermal vacuum breadboard power processor and a propellant feed system will be continued in FY 1977. This test simulates operation of the ion engine system in a representative type of satellite north-south station keeping application. In addition, modularization investigations of this engine to accommodate higher thrust levels (2 to 4 millipounds) will be continued.

In the area of primary solar electric propulsion, a 30-centimeter (2.75 kilowatts) mercury ion engine completed 10,000 hours of testing before shut-down, and initial testing of a thermal vacuum breadboard power processor for the 30-centimeter engine was also completed. A 15,000 hour endurance test of an improved 30-centimeter ion engine containing material changes to the engine ion chamber to reduce internal erosion will be continued in FY 1977. In addition, testing of a number of engines in an array configuration to determine interactions will be initiated in FY 1977 as well as the fabrication of a function model power processor for the engine. Final design of a large (12.5 kilowatt wing), light weight (15 kilograms per kilowatt) solar array for solar electric propulsion applications was completed in FY 1976.

Supporting the above work in auxiliary and primary electric propulsion is a continuing effort of basic research aimed at better understanding the processes limiting life and efficiency. In addition, work on exploring various potential applications of the ion beam for other uses, such as surface cleaning, material coating, drilling, etc., will be continued.

Space Energy Systems Research and Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
8,170	7,290	7,810	2,200	1,800	7,800

OBJECTIVES AND STATUS:

The objectives of the Energy Systems Research and Technology program are to make available low-cost, long-lived, reliable, high power-density and high energy-density components and technology for spacecraft energy systems.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

The increase of $520 thousand over the budget estimate is to provide for funds to study high-voltage interactions, particularly between the spacecraft and its surroundings, which have caused problems in the past. This is a joint NASA/Air Force program.

Transition Quarter Estimate:

The decrease of $400 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the Transition Quarter. The reduction of funding will result in deferral into FY 1977 of a portion of the contractual effort on the high-voltage interaction study, of preparation of a power systems design handbook and of the design of a high temperature solar cell array.

BASIS FOR FY 1977 ESTIMATES:

Work on solar cells and arrays will emphasize high end-of-life efficiency for the cells and high power density for arrays. A better understanding of radiation damage is being achieved and will be used for selecting a specific design and initial fabrication of cells with efficiencies over 13-14 percent. In addition, design of a 200-watt per kilogram solar array will be initiated.

The non-gassing construction of nickel oxide-cadmium battery cells will be combined with light weight types of structures, some developed in the fuel cell program, to about triple the usable energy density of such batteries, without sacrifice in life and reliability. The accelerated, non-destructive test program for battery cells will be simplified so it can be used by spacecraft engineers in selecting battery components. Fuel cell tests will stress life expectancy of light weight cells run on reactant-grade (impure) propellants at low pressure.

A power processing and distribution design handbook will be written to systematize existing information and guide future designers. The plan, developed in FY 1976 for automatic power systems management, will be implemented partially in FY 1977, in preparation of use of these techniques in planetary-type spacecraft. Automatic test and charge equipment will be developed for individual cell control in battery management to attain higher reliability by lower stress levels of cells. Work will proceed jointly with the Air Force on developing ground simulation, spacecraft modeling, and testing techniques to better understand spacecraft charging and to arrive at solutions.

In the area of thermal-to-electric energy conversion, delivery of the mini-Brayton (0.5 - 2.0 kilowatt) components to the Energy Research and Development Administration will be completed, in preparation for the simulated electrical ground system in FY 1978. The larger (2 - 15 kilowatt) Brayton rotating unit test will be continued towards the goal of 50,000 hours of operation, almost half of which has been attained. Life testing of thermoelectric materials also will be extended, and newer, high-efficiency couples will be evaluated in cooperation with the Energy Research and Development Administration.

Nuclear Energy Research and Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
2,188	2,200	2,025	700	600	2,000

OBJECTIVES AND STATUS:

The objective is to provide the basic research and technology for the potential utilization of nuclear power for future space missions.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

The FY 1976 decrease of $175 thousand reflects lower than anticipated costs of services in support of the in-house nuclear energy research efforts.

Transition Quarter Estimate:

The decrease of $100 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the Transition Quarter. The reduction of funding will result in deferral of research on transuranium nuclear waste incineration into FY 1977.

BASIS OF FY 1977 ESTIMATES:

Research in the field of thermionic energy conversion has the 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 be advantageous for nuclear electric propulsion in space and for topping cycles in terrestrial power plants. In FY 1977, research on the physics of emitter and collector materials, and on the inter-electrode plasma will be emphasized. In addition, preliminary systems studies will continue on the applications of thermionic converters in topping cycles and nuclear electric generating systems.

The main thrust of the gaseous fuel reactor research is directed toward a benchmark experiment for the demonstration of the feasibility and benefits of this concept of advanced nuclear energy utilization. Valuable reactor components salvaged from the previous NASA nuclear rocket program will be used. In FY 1976, reactor experiments were begun with static gaseous uranium hexafluoride fuel loadings and will continue through FY 1977. In addition, preparations for flowing fuel loadings will be made, and basic research on the radiation from fissioning gases will continue. Future benefits of this research include electric power generation with up to 70 percent efficiency and the conversion of nuclear energy directly into work in the form of laser beams, with significant safety factors such as minimum critical mass, minimum radioactive waste inventory and the incineration of long-lived waste products in the reactor.

High Power Lasers and Energetics
Research and Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
4,965	5,410	5,200	1,600	1,400	5,200

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 be applicable to the problem of meeting the long range energy needs on Earth.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimates:

The FY 1976 decrease of $210 thousand reflects lower than anticipated costs of services in support of the in-house lasers and energetics research efforts.

Transition Quarter Estimates:

The decrease of $200 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the Transition Quarter. The reduction of funding will result in deferral of research on photochemistry into FY 1977.

BASIS OF FY 1977 ESTIMATES:

Research in the area of plasmadynamic energy systems includes a project to investigate combustion-driven Magnetohydrodynamic (MHD) generators for very high power densities. Combustor experiments were conducted during FY 1976. Superconductive magnets are under development 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 in MHD power generation. In FY 1977, preliminary tests will be conducted to match combustor and magnets. The large superconducting magnetic mirror apparatus (SUMMA) designed to produce fusion-like plasmas became fully operational in FY 1976. In the

future it will be used for research on the principles of how to use fusion plasmas in space. In FY 1977, techniques will be developed and tested to diagnose the 100 million degrees Fahrenheit hot plasmas.

In magnetics and cryophysics, cryogenic cooling was demonstrated with a small magnetic heat pump during FY 1976. A highlight in the FY 1977 period will be the demonstration of techniques to fabricate long samples of superconductive ribbons by means of a novel germanium-niobium vapor deposition technique.

In fundamental photonics, basic research is concentrated on the emission and absorption of radiation from all states of matter in support of power generation, propulsion, lasers, space environment, and atmospheric physics. In FY 1976 the direct conversion of fission fragment energy into coherent light was attempted, in a nuclear powered high pressure xenon laser, for large power in the visible spectrum. This effort will continue through FY 1977, along with other work in the area of photon-matter interactions.

A program of high power laser systems research is being conducted to determine whether lasers can be made that could have a major impact on aerospace mission capabilities. A continuously operating closed-loop laser will come into operation in FY 1976-1977 and will be studied to determine what technical barriers may exist in long duration operation at high power levels. In addition, 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 1977.

Entry Research and Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
5,677	5,700	5,700	1,700	1,500	5,700

OBJECTIVES AND STATUS:

The objective is to establish the aerothermodynamic technology and design concepts of spacecraft entering Earth and other planetary atmospheres to assure the timely design of safe, reliable and aerodynamically efficient spacecraft with maximum payload and increased operational capabilities.

CHANGES FROM BUDGET ESTIMATES:

Transition Quarter Estimate:

The decrease of $200 thousand reflects adjustments required to absorb part of the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for the Transition Quarter. This reduction resulted in rephasing of selected entry research efforts originally planned for this period.

BASIS OF FY 1977 ESTIMATES:

During FY 1977 entry research will continue on advanced Earth-orbital transportation systems concepts. In FY 1977 this effort will be directed toward: establishment of the aerodynamics of a baseline and control configured single stage to orbit vehicles; evaluation of the application of a linear rocket engine to advanced space transportation systems; development of interactive design programs and heat transfer measurements of the first series of advanced vehicle concepts. The impact of environmental constraints such as sonic boom and effects on the atmosphere will be determined for each concept developed.

The program also supports missions to study the atmospheres of the inner and outer planets. The hypervelocity entry vehicle heating and aerodynamic environment of probes entering these atmospheres will be defined to assure survival and reliable performance of scientific probes during entry. Candidate configurations for deep space planetary probes will be assessed and the radiation blockage effectiveness of ablation products for probes entering planetary atmospheres will be evaluated.

In FY 1977, the program will continue to support the Space Shuttle by providing extensive use of ground-based facilities and expertise as required by the Office of Space Flight. Shuttle technology studies will be continued. The thrust during this time period will be directed toward developing a better understanding of the specific-heat-radio effects upon aerodynamic heat transfer and boundary layer transition; evaluating piloted and auto-control operation of orbiter with emphasis upon approach and landing tests; and providing support as required on problems that may arise.

BASIS OF FUND REQUIREMENTS:

Systems Studies

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
1,600	1,600	1,825	400	400	1,600

OBJECTIVES AND STATUS:

The objectives of the Space Systems Studies are to identify and evaluate the technology requirements of advanced system candidates, investigate future space mission alternatives, assess the effects of technology advances, and provide a data base to support technology program selection and program planning.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate:

The increase of $225 thousand reflects an adjustment to provide for a study to determine the feasibility of detecting extra-terrestrial intelligence through signal detection and processing.

BASIS OF FY 1977 ESTIMATES:

With emphasis on contributing to research and development technology planning, the studies will continue to examine: the development of future program technology needs; subsequent determination of detailed technology requirements; alternative solutions for satisfying needs and requirements; and the process of ordering and prioritizing these options.

Studies to determine long-term mission enabling technology needs will continue to receive major emphasis during FY 1977. Data management, instrument development and detector research studies will be pursued. Study efforts are planned to project flight software requirements as well as total end-to-end software needs. Efforts will continue to catalogue current and forecasted capabilities of other agencies relevant to NASA's long-term enabling technology needs.

Future mission and concept feasibility studies such as single-stage-to-orbit launch systems, solar and nuclear electric powered spacecraft missions, solar sailing feasibility and detection of extra-terrestrial communication signals will continue to aid in the identification of technology opportunities and needs. Technology readiness studies will serve to assess the benefits and risks of committing to technology advances and improvements for application to near-term programs of the Agency.

The evaluation of the current research and technology programs in the context of technology objectives will continue. Analytical decision analysis methodology will continue to be developed and evaluated.

BASIS OF FUND REQUIREMENTS:

Systems Technology Programs

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Materials and structures system technology	---	500	500	300	300	1,500
Guidance, control and information system technology	800	700	700	300	300	900
Space propulsion system technology	---	---	---	---	---	700
Entry system technology	875	1,000	1,000	200	---	---
Total	1,675	2,200	2,200	800	600	3,100
Materials and Structures Systems Technology	---	500	500	300	300	1,500

OBJECTIVES AND STATUS:

The objective is to demonstrate the validity of advanced materials and structures technologies to facilitate early transfer to application in space vehicle system design. Critical system applications are selected for design, fabrication, and laboratory testing followed by space flight testing if necessary and appropriate.

BASIS OF FY 1977 ESTIMATES:

The goal of the Composites for Advanced Space Transportation Systems (CASTS) program is to develop a practical polyimide resin composite system that can operate at 600 degrees Fahrenheit. In FY 1977 materials evaluations and trade studies will be completed, and a component of the Shuttle will be selected as a representative demonstration article to be fabricated with advanced graphite-polyimide composites and laboratory tested to substantiate structural integrity and efficiency. Specifications for the design, fabrication, and evaluation of the test article will be established. Completion of the laboratory tests is targeted for FY 1982.

Guidance, Control and Information Systems Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
800	700	700	300	300	900

OBJECTIVES AND STATUS:

The objective of this systems technology program is to demonstrate improved performance, increased reliability and reductions in cost of spacecraft guidance, control and information systems. Advanced electronic devices and system concepts are integrated with appropriate supporting technology to provide tests and evaluate their capabilities in functional system applications.

BASIS OF FY 1977 ESTIMATES:

A Solid State Data Storage system development program was initiated during FY 1976. A system design based on the use of magnetic "bubble" domains as the storage media was selected. A 15 month contract was let in October 1975 to develop an engineering model of the data storage system. Design goals are to provide a system capable of storing 10^8 bits of digital data with a reliability of 2×10^4 hours for aerospace vehicle applications.

The engineering model solid state data storage system effort will be completed early in the second quarter of FY 1977. Tests and evaluation sufficient to prove the technical feasibility of the concept will be performed during the second and third quarters of FY 1977. Development of a prototype model capable of full

system operation will then be initiated with completion, testing and qualification to space flight standards planned by the end of FY 1978.

A Multiple-User Software Technology Program (MUST) will be initiated in FY 1977. Automated flight software generation and verification techniques will be developed to reduce acquisition costs and increase system reliability. A Simple Higher Order Language (SHOL) to fit user software needs will be defined. The program includes development of a generalized compiler writing system to permit automated conversion of user-specific software into the particular assembly language of candidate flight computers and validation routine. In subsequent years, the multi-purpose, user-oriented software systems will be verified to provide a NASA standard by the end of FY 1981.

Space Propulsion and Power Systems Technology

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
---	---	---	---	---	700

OBJECTIVES AND STATUS:

The objective of this program is to demonstrate technology readiness of advanced space propulsion and power system by conducting tests of complete systems assembled from advanced technology components already demonstrated under the Research and Technology Base Program. The system level tests are designed to evaluate component interactions and to demonstrate overall system performance and operation, under both transient and steady state operating conditions.

BASIS OF FY 1977 ESTIMATES:

The goal of the Long Life Chemical Propulsion program is to demonstrate technology readiness by FY 1980 of an advanced planetary orbiter spacecraft propulsion system utilizing high performance space storable fluorine-hydrazine propellants. The objective will be met by the design, fabrication, assembly and test of a near flight weight propulsion module under simulated space vacuum conditions. The program will include the demonstration of overall propulsion system performance and operation, and establishment of handling, safety and launch operation procedures. The FY 1977 work will include the design and analysis efforts to define the propulsion system configuration and to establish component operational requirements, the initiation of component procurements, including propellant tanks and valves, thermal control and thrust chamber

assembly, and the establishment of a test plan and test procedures. Component fabrication will be completed in FY 1978 and verification testing in FY 1979. The complete propulsion system will be assembled in FY 1979 and simulated space vacuum testing is scheduled for completion in FY 1980.

BASIS OF FUND REQUIREMENTS:

Experimental Programs

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Space technology payloads.....	2,000	3,700	3,700	1,100	1,100	6,900

OBJECTIVES AND STATUS:

The objective of this program is to provide the Office of Aeronautics and Space Technology (OAST) the means to extend its Research and Technology Programs into space when that unique environment is essential to an experiment, when a space test is cost effective, or when a space demonstration will accelerate the utilization of advanced technology. The program defines and develops facilities which can take advantage of the Shuttle and Spacelab capability, thereby providing a means to conduct research and technology investigations in space; it also defines, develops and implements space experiments in specific technology areas which utilize these facilities on the Shuttle and Spacelab.

BASIS OF FY 1977 ESTIMATES:

Two space facilities are currently included in the program. The Long Duration Exposure Facility (LDEF) is a passive, free-flying satellite designed to accommodate a large number of exposure type experiments. Essential to the concept is the return of the experiment to the investigator for data analysis after the space exposure. In FY 1977 hardware activities will be well advanced, qualification tests of key items will be conducted, and flight acceptance tests will be initiated. In response to the Announcement of Opportunity for the first LDEF mission, which is proposed as part of the Orbiter Flight Test Program,

selected experiments will be funded and hardware development and implementation will be initiated. A systems design study of the Advanced Technology Laboratory (ATL) concept, which is OAST's use of Spacelab, will be completed and a definition study for the first ATL mission will be initiated.

As a result of the OAST Technology Workshop, held August 1975, which identified nearly 200 space experiment needs, definition studies in specific technology areas have been initiated. The first results of these studies will be available in FY 1977, and several experiments will be selected for development and implementation. Two flight payloads in the implementation phase are the Drop Dynamic Experiment Module, which is being considered for the joint NASA/ESA Spacelab mission, and a contamination monitor for the first Shuttle flights. The Drop Dynamics Flight unit will be assembled in FY 1977 and functional testing will be initiated. The Contamination Monitor Instruments will be received by FY 1977 and integration into the flight unit will be initiated.

BASIS OF FUND REQUIREMENTS:

Low Cost Systems

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Low Cost Systems Program.....	5,000	6,100	6,100	1,500	1,500	8,300

OBJECTIVE AND STATUS:

The Low Cost Systems Program was established to prescribe approaches toward reducing the overall cost of space systems by developing standardized space equipment and components and by searching NASA's business and program practices for opportunities to effect cost savings.

The objectives of reducing the cost of space projects will be accomplished by:

- Simplifying operations without compromising reliability and enhancing cost effectiveness for space programs through common usage of equipment and software,
- Streamlining business approaches to shorten the time required for approval and implementation, and
- Improving program practices to increase efficiency and reduce costs.

The standardization program is implemented in five sub-categories: Power; Auxiliary Propulsion; Stabilization, Guidance and Control; Communications and Data Handling; and Ground Support Equipment.

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.

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.

Stabilization, Guidance and Control

The objectives in this area are to identify, develop and qualify stabilization, guidance and control equipment and software that has utility for various space flight programs.

Communications and Data Handling

The objectives are to coordinate mission requirements, and develop and qualify standardized flight equipment for spacecraft communications and data management.

Ground Support Equipment (GSE)

The objective is to reduce cost by standardizing on existing GSE where practical to effect cost savings and to develop standardized GSE where it is proven to contribute to cost savings.

BASIS OF FY 1977 ESTIMATES:

In FY 1977, the Low Cost Systems Program will continue to implement approaches for further reducing the cost of space projects through standardization and the improvement of business and program practices. Development areas of specific emphasis include: solar array panels, solar panel mechanical drive, and power processors; standard hydrazine, attitude control propulsion components; standard inertial reference unit; standard computer, transponder telemetry and command components, detector; and ground support equipment software and a ground support equipment set.

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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1977 ESTIMATES

BUDGET SUMMARY

OFFICE OF ENERGY PROGRAMS

ENERGY TECHNOLOGY APPLICATIONS

SUMMARY OF RESOURCES REQUIREMENTS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Energy Technology Applications	4,435	5,900	5,900	1,500	1,500	---
Distribution of Program Amount by Installation:						
Johnson Space Center	43	1,875	1,315	375	180	---
Kennedy Space Center	---	50	---	25	---	---
Marshall Space Flight Center	615	250	525	50	235	---
Goddard Space Flight Center	75	225	160	75	25	---
Jet Propulsion Laboratory	2,399	2,500	1,900	675	700	---
Ames Research Center	160	175	185	75	50	---
Langley Research Center	160	75	---	25	---	---
Lewis Research Center	555	750	1,815	200	310	---
Headquarters	428	---	---	---	---	---
Total	4,435	5,900	5,900	1,500	1,500	---

OFFICE OF ENERGY PROGRAMS

ENERGY TECHNOLOGY APPLICATIONS

PROGRAM OBJECTIVES AND JUSTIFICATION:

The technology developed in the Space and Aeronautics programs conducted by NASA holds potential for significant contributions to the solution of energy problems on Earth. In 1974, NASA organized the Office of Energy Programs to focus efforts directed toward the identification and experimental development of the technologies holding greatest promise in the energy area. For FY 1977 NASA direct R&D funding for these activities has not been requested. NASA will continue to apply its expertise and capabilities in these areas by conducting research and development activities as requested and funded by the Energy Research and Development Administration (ERDA) and other agencies.

During FY 1975, FY 1976, and the Transition Quarter, NASA had direct R&D funding to carry out initial technology identification and refinement activities. Technology identification activities include work relating to advanced ground propulsion, reduction of the drag in large road vehicles, multipurpose gas turbines, hydrogen energy systems, fuel cells for down-to-earth applications, energy storage systems, energy resources identification, and integrated utility systems. The objective of the energy systems technology activities is to assess the technology related to the generation of electric power from solar energy, using power stations in geosynchronous orbit, and the transmission of this electricity to Earth. In FY 1975, NASA established a satellite power system study team for the purpose of evaluating the economic and technical feasibility of the production, transmission and utilization of large amounts of electricity generated by solar power stations in orbit about the Earth. A preliminary study indicated that satellite power generation could be cost competitive in the 1990's. Satellite power systems definition efforts have been 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. Appropriate areas for study activity in FY 1977 include systems definition, microwave energy transmission, space structures, transportation, attitude control and station keeping, power conversion, operations and environmental effects. Negotiations are underway with ERDA for reimbursable funds to support these initial study and definition efforts which are required to develop a sufficient understanding of the technical and economic practicability of the Satellite Solar Electric Power Generation System concept in order to permit a basis for evaluation of a potential commitment to technology development.

In addition, reimbursable agreements have been negotiated with ERDA for NASA support of Residential and Commercial Solar Heating and Cooling, Wind Energy, Solar Photovoltaics (solar cells), and Geothermal Energy programs. These plans are already being implemented.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1977 ESTIMATES

BUDGET SUMMARY

OFFICE OF TRACKING AND DATA ACQUISITION — TRACKING AND DATA ACQUISITION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Operations	192,600	192,400	193,500	51,200	50,100	206,800
Systems implementation	42,500	41,400	38,100	12,900	11,000	42,500
Advanced systems	9,300	9,200	9,200	2,300	2,300	8,700
Tracking and data relay satellite system	3,600	---	---	---	---	---
Total	248,000	243,000	240,800	66,400	63,400	258,000
Distribution of Program Amounts by Installation:						
Marshall Space Flight Center	4	---	---	---	---	---
Goddard Space Flight Center	175,949	169,100	167,800	45,300	44,200	181,900
Jet Propulsion Laboratory	49,297	51,500	51,800	15,300	14,350	54,800
Wallops Flight Center	5,057	5,100	4,300	1,400	1,250	4,800
Flight Research Center	2,470	2,400	2,300	600	600	2,500
Headquarters	15,223	14,900	14,600	3,800	3,000	14,000
Total	248,000	243,000	240,800	66,400	63,400	258,000

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, commercial firms, 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 on-board 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 worldwide network of NASA ground stations and one 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 communications carriers, both domestic and foreign. This interconnection provides the communications capability between spacecraft and the control centers in the United States from which the flights are directed.

Computation facilities also are provided to process into meaningful form the large amounts of scientific, applications and engineering data which are collected from flight projects. In addition, instrumentation facilities are provided for support of sounding rocket launchings and flight testing of aeronautical research aircraft.

The Research and Development (R&D) appropriation provides funds for: (a) the operation and maintenance of the worldwide facilities; (b) the engineering and procurement of equipment to sustain and modify the network systems to support continuing, new, and changing flight project requirements; and (c) the investigation of advanced tracking and data acquisition techniques and the development of advanced tracking and data acquisition instrumentation.

CHANGES FROM BUDGET ESTIMATES:

The decrease in the FY 1976 budget estimates reflects Congressional authorization action reducing the Tracking and Data Acquisition budget request by $2.2 million. The decrease of $3 million in the Transition Quarter budget estimate was required as part of the adjustments necessary to absorb the overall unspecified Congressional reduction of $30 million in NASA's Research and Development budget request for this period. As a net result of these reductions and increased operations costs due to escalation, equipment purchases originally scheduled for FY 1976 and the Transition Quarter are being deferred into early FY 1977.

BASIS OF FUND REQUIREMENTS:

Operations

The FY 1977 Operations funding requirements are based upon a continuing support workload for an average of 50 automated earth-orbiting and planetary missions. The funds will also provide for the pre-launch support activity required for upcoming approved missions. The increase in the FY 1977 requested funding level for Operations is due to the escalation being experienced in both overseas and domestic tracking operations.

	1975	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
			(Thousands of Dollars)			
Spaceflight tracking and data network	102,400	97,000	99,200	26,000	26,000	108,800
Deep space network	37,489	38,400	40,500	10,200	10,400	43,000
Aeronautics and sounding rocket support	4,197	4,100	3,800	1,100	1,000	4,200
Communications	26,038	27,900	26,000	7,000	6,500	26,000
Data processing	22,476	25,000	24,000	6,900	6,200	24,800
Total	192,600	192,400	193,500	51,200	50,100	206,800

Spaceflight Tracking and Data Network Operations

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
102,400	97,000	99,200	26,000	26,000	108,800

OBJECTIVES AND STATUS:

The primary function of the Spaceflight Tracking and Data Network is to support manned and unmanned earth orbital space flight missions. The majority of these missions have near-earth orbits; however, the network also supports missions through lunar distances. In addition, the nerwork provides launch support to NASA's automated planetary missions, as well as the spaceflight missions of other nations, commercial firms, the Department of Defense, and other U.S. Government agencies.

The Spaceflight Tracking and Data Network must be responsive to the requirements of a large number and wide variety of flight projects from launch through completion of the flight project objectives. In many instances, the period of network support required by the flight projects continues for several years.

The Spaceflight Tracking and Data Network presently consists of thirteen geographically dispersed land stations, one instrumented ship, and a control center complex located at the Goddard Space Flight Center, Greenbelt, Maryland.

These global facilities have the capability to electronically track the spacecraft, send commands for spacecraft and experiment control purposes, receive engineering and scientific data from the spacecraft, and in the case of the astronauts maintain voice communications for crew safety and other project related purposes. In addition to these electronic systems, the network is supplemented by laser tracking systems to meet the extremely precise tracking needs of NASA's geodetic investigations.

The thirteen land stations are located at Fairbanks, Alaska; Goldstone, California; Merritt Island, Florida; Kauai, Hawaii; Rosman, North Carolina; Guam; Ascension Island; Australia; Bermuda; Chile; Ecuador; England; and Spain. The transportable facility is located at Madrid for support of the Applications Technology Satellite (ATS-6) operations. A second transportable station, which was previously located near St. John's, Newfoundland, for Skylab and Apollo Soyuz Test Project support, is being refurbished and will be relocated to a new site at NASA's Flight Research Center (FRC), Edwards, California. This facility will be staffed in FY 1977 for support of the Shuttle Approach and Landing Tests scheduled to begin in late 1977.

The Space Flight Tracking and Data Network is currently providing support on a continuing basis for an average of approximately 40 unmanned applications and space science spacecraft. Major examples include support of missions such as the first two Earth Resources Technology Satellite (LANDSAT 1 and 2), the several Applications Technology Satellites and Interplanetary Monitoring Plarform Satellites, the eighth Orbiting Solar Observatory (OSO-8), Orbiting Astronomical Observatory (OAO-3), a Radio Astronomy Explorer (RAE-2), Space Science Atmosphere Explorers (AE-3, 4 and 5), Nimbus-4, 5 and 6, and Geodynamics Experimental Ocean Satellites (GEOS-2 and 3). The network is also continuing to receive valuable scientific data from the Apollo Lunar Surface Experiment Packages (ALSEP) placed on the moon's surface during the Apollo 12, 14, 15, 16 and 17 missions.

Upcoming missions to be supported by the network include the High Energy Astronomical Observatory (HEAO), a Laser Geodynamic Satellite, (LAGEOS), and the International Ultraviolet Explorer (IUE), as well as many international missions and missions of other U. S. agencies. The overall workload of the Space Flight Tracking and Data Network is expected to continue at an average of approximately 40 spacecraft during FY 1977. The density of the workload requirements is reflected in the accompanying charts.

CHANGES FROM BUDGET ESTIMATES:

The upward adjustment of $2.2 million in the FY 1976 funding requirements reflects higher than anticipated cost escalation for the operation of the Spaceflight Tracking and Data Network. The current Transition Quarter estimate remains the same as the budget estimate.

BASIS OF FY 1977 ESTIMATES:

The FY 1977 funding requirements for the Spaceflight Tracking and Data Network operations provide for the maintenance and operation of the network facilities, as well as the related logistics, network support, and computer programming costs associated with the around-the-clock operation of the network. The projected increase from FY 1976 to FY 1977 is due to significant escalation in both labor and logistics costs throughout the network. The impact of escalation has been particularly significant in Spain, Australia, and Alaska, with annual labor rate and fringe benefit increases being experienced on the order of eighteen to thirty percent at these locations.

Deep Space Network Operations

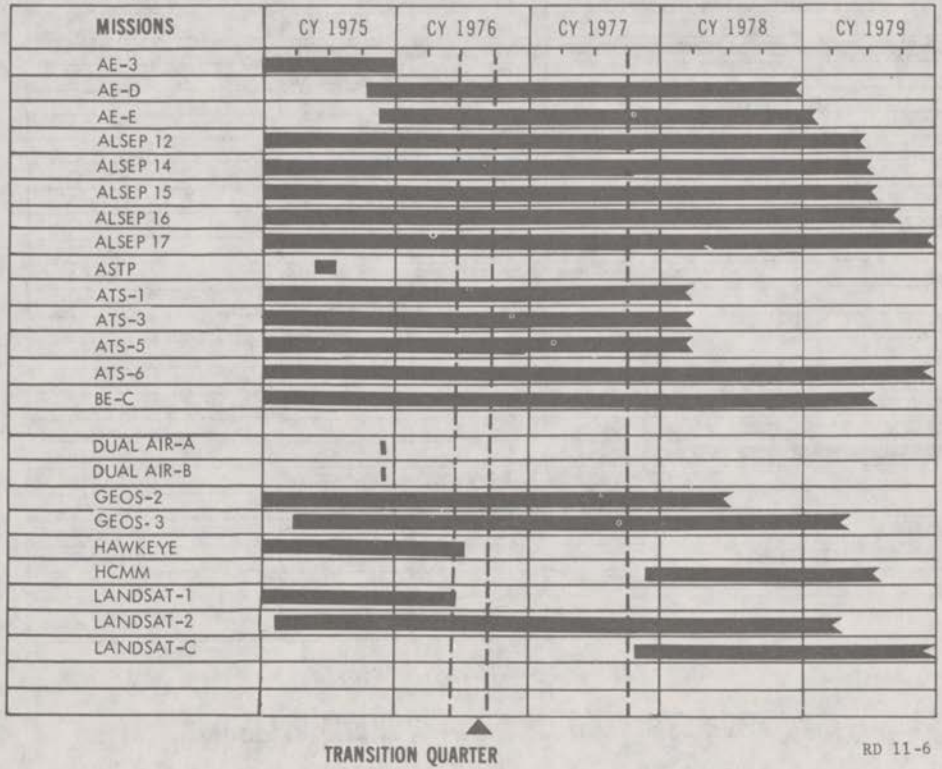
	1976		Transition Quarter		1977
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)			
37,489	38,400	40,500	10,200	10,400	43,000

RD 11-5

SPACEFLIGHT TRACKING AND DATA NETWORK WORKLOAD

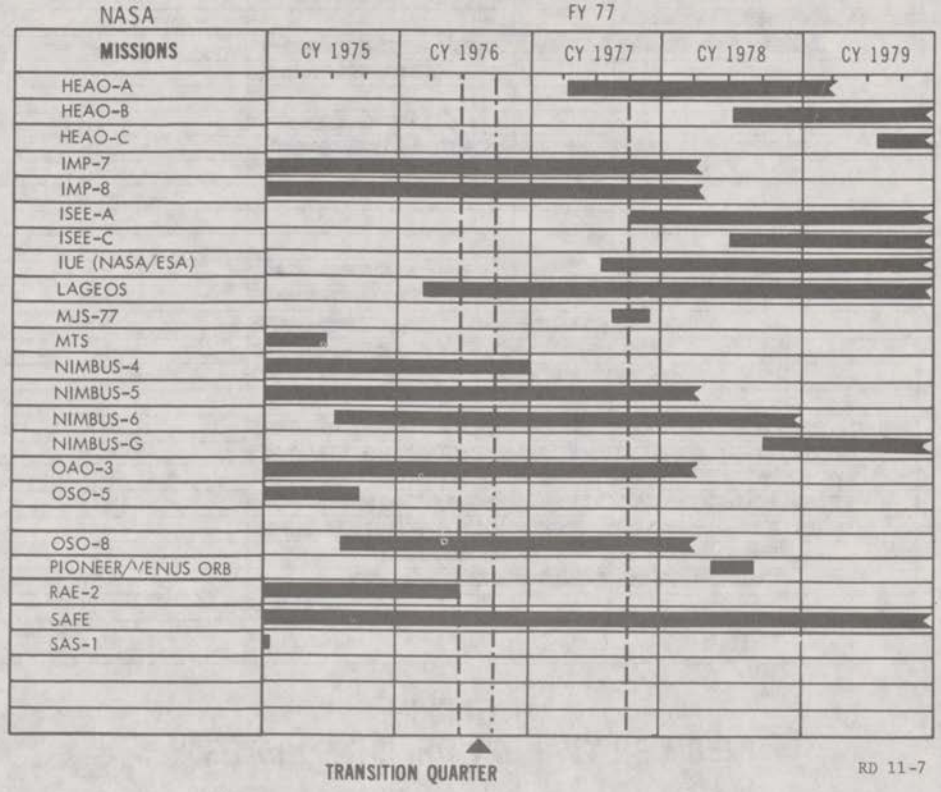
NASA

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SPACEFLIGHT TRACKING AND DATA NETWORK WORKLOAD

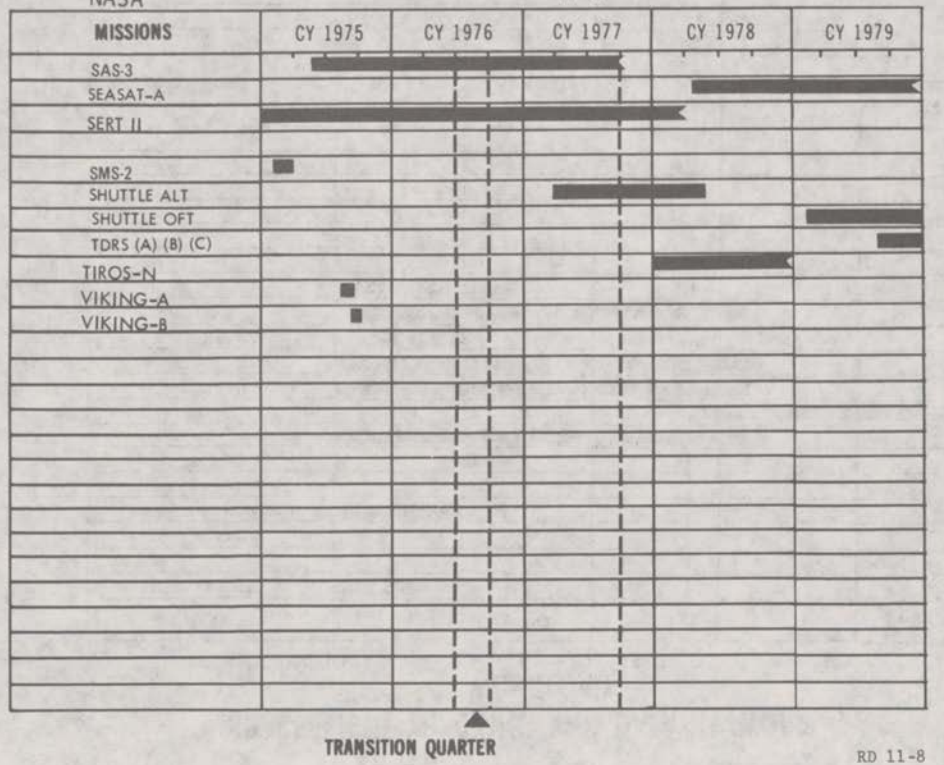


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SPACEFLIGHT TRACKING AND DATA NETWORK WORKLOAD

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FY 77

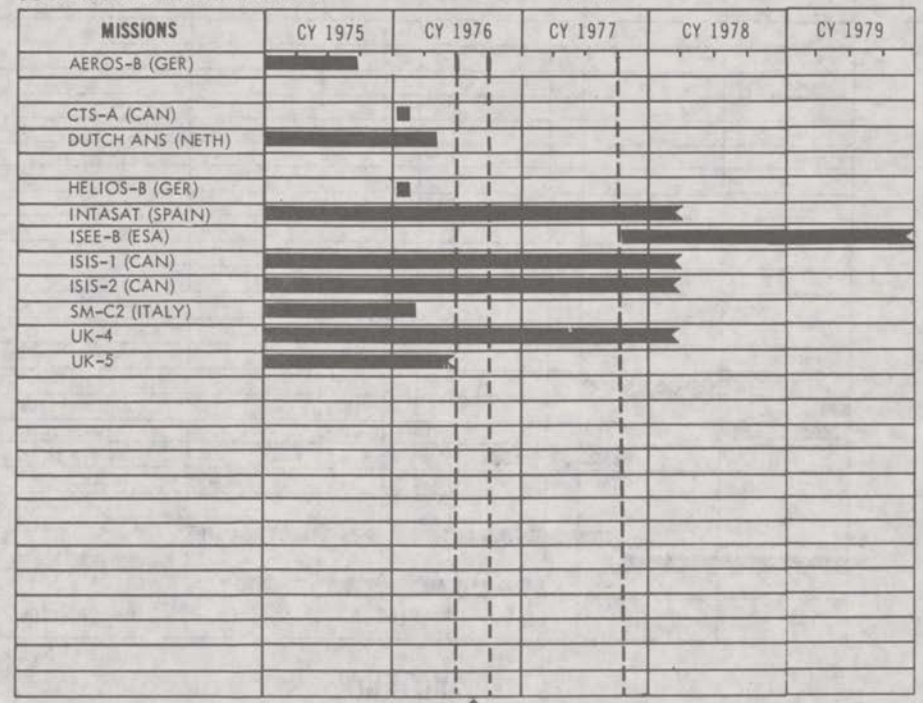


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SPACEFLIGHT TRACKING AND DATA NETWORK
WORKLOAD

COOPERATIVE INTERNATIONAL

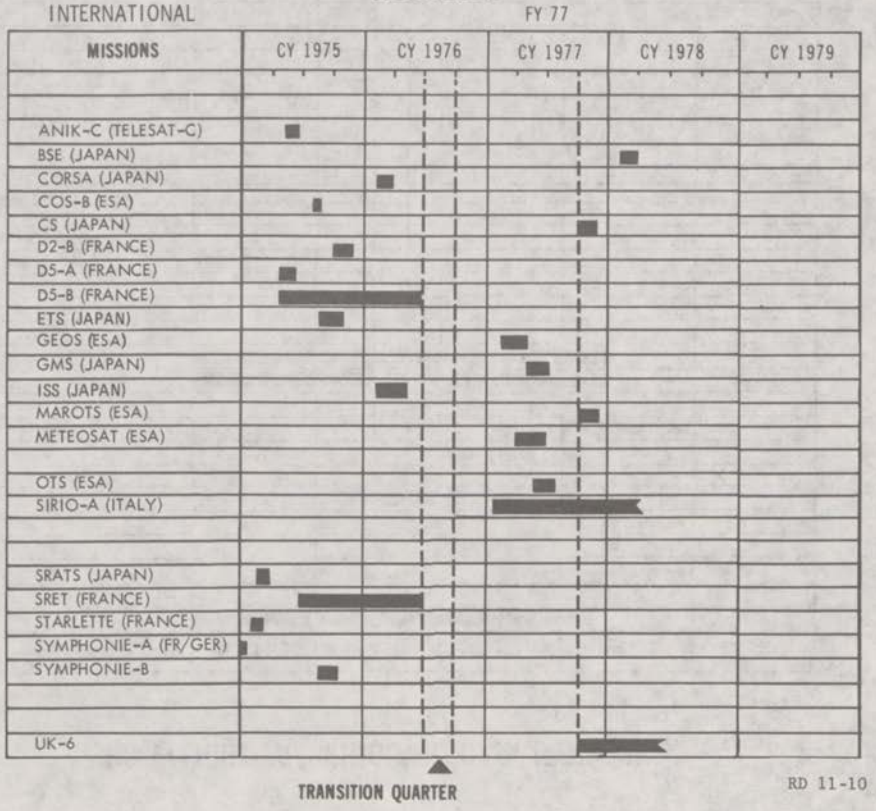
FY 77



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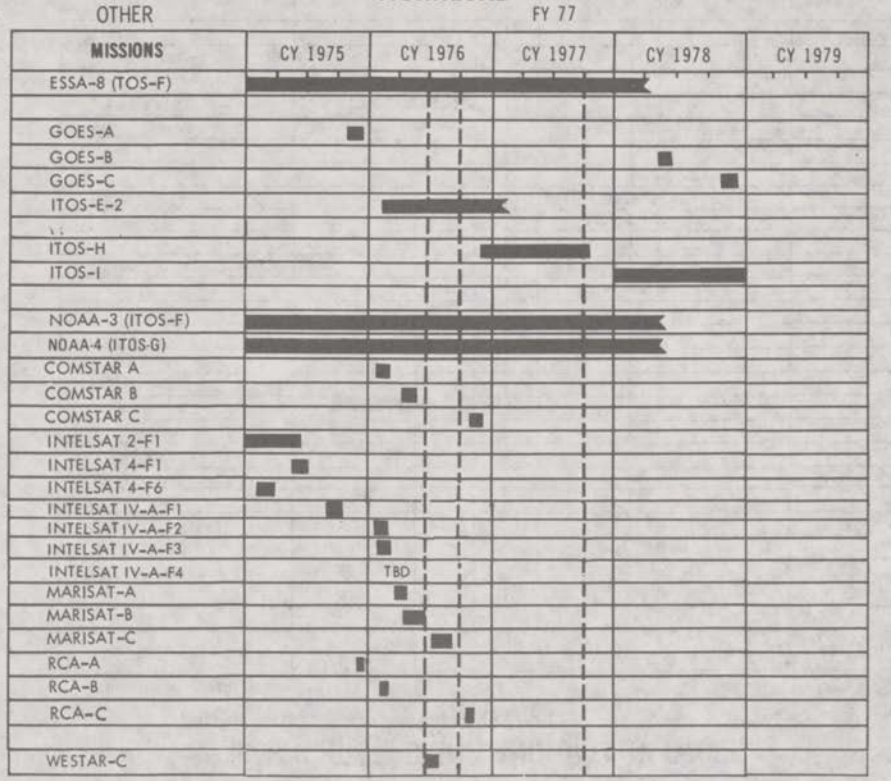
SPACEFLIGHT TRACKING AND DATA NETWORK WORKLOAD

INTERNATIONAL



RD 11-10

SPACEFLIGHT TRACKING AND DATA NETWORK WORKLOAD

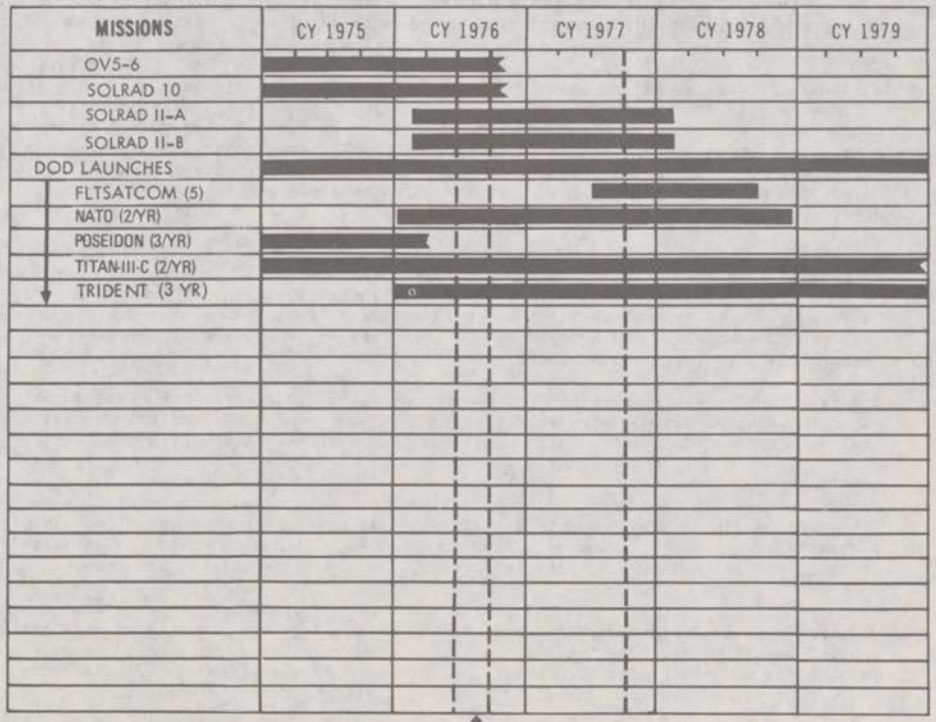


RD 11-11

SPACEFLIGHT TRACKING AND DATA NETWORK WORKLOAD

DEPT. OF DEFENSE

FY 77



RD 11-12

OBJECTIVES AND STATUS:

The primary function of the Deep Space Network (DSN) is to support planetary and interplanetary space flight missions. As the planetary missions become more complex and flight distances continue to increase, this network requires systems, software programs, and operational techniques that push the state-of-the-art in telecommunications. The Deep Space Network provides the vital two-way communication link by which the distant spacecraft are controlled and scientific data are acquired.

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. These locations are approximately 120° apart in longitude and permit continuous viewing of the planetary spacecraft. A centralized control center for the network is located at the Jet Propulsion Laboratory in Pasadena, California.

The current workload in the Deep Space Network consists of the six ongoing Pioneer spacecraft, the two Viking spacecraft, which require continuous support, and the Helios 1 mission. Support to these missions, as well as a second Helios mission, successfully launched in January 1976, will continue during FY 1977.

Of the Pioneer spacecraft, Pioneer 10 is already over 1.3 billion kilometers from Earth and is proceeding on a path to escape the solar system. Pioneer 10 is the most distant man-made object ever communicated with and each time data is received a new communications record is established. The Pioneer 11 spacecraft is also being tracked during its journey to the planet Saturn and is scheduled to fly by that planet during the last half of 1979. The Pioneer 6-9 spacecraft are provided support for coverage of special events, such as solar conjunction.

The two Viking missions, each consisting of an orbiter and a lander spacecraft, were successfully launched in August and September 1975, respectively, and are continuing enroute to Mars for landings in mid 1976. Viking is the most complex planetary mission ever supported by the Deep Space Network. In the planetary phase of the missions, the network must simultaneously handle data from the two Viking orbiters and landers at a distance of approximately 350 million kilometers from Earth and with a round trip signal time of some 40 minutes. Two Mariner-class spacecraft are scheduled for launch in 1977 on a course to Jupiter and on to Saturn, taking advantage of a rare alignment of these two outer planets. Network support preparations for these missions are continuing.

The Deep Space Network facilities are also used for ground-based measurements in support of experiments in planetary radar mapping and in the field of radio astronomy. The extra-sensitive network antennas are being used in an attempt to learn more about the mysterious Quasar high energy sources and other interstellar phenomena. During FY 1977, support of these radio astronomy experiments will continue on a non-interference basis to the flight missions.

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CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate: The increase of $2.1 million in the current FY 1976 funding level from the budget estimate is due to higher than anticipated cost escalation and increased engineering effort required in the network for support of the Viking and Mariner Jupiter/Saturn 1977 missions.

Transition Quarter Estimate: The increase of $200 thousand from the budget estimate to the current estimate is due to cost escalation.

BASIS OF THE FY 1977 ESTIMATES:

The FY 1977 funds requested for the operation of the Deep Space Network are based upon the ongoing workload, including the Pioneer spacecraft, the Viking and Helios extended missions, and preparations for the Mariner Jupiter/Saturn 1977 (MJS 1977) missions. This workload is shown on the accompanying chart.

The two Mariner Jupiter/Saturn spacecraft scheduled for launch in 1977 will impose stringent support requirements on the DSN and will require extensive pre-launch engineering and testing. The Pioneer Venus missions to be launched in 1978 will also require extensive pre-launch engineering support, especially in preparation for the precision tracking of the entry probes during their descent through the dense Venusian atmosphere.

As in the Space Flight Tracking and Data Network, cost escalation is the most significant factor requiring an increased funding level for FY 1977 over FY 1976.

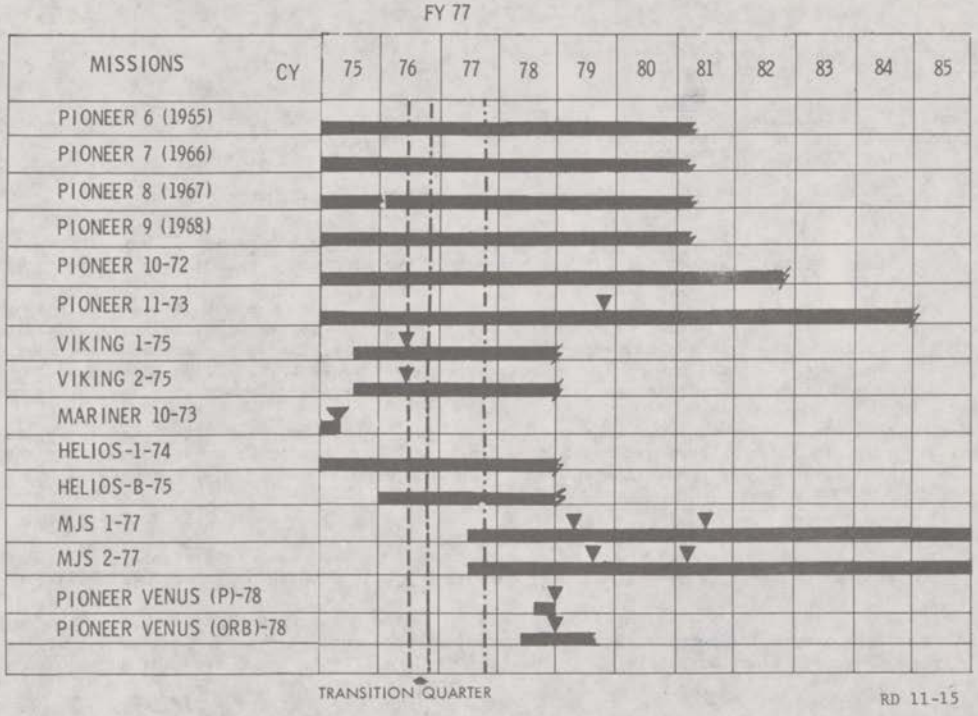
Aeronautics and Sounding Rocket Support

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
4,197	4,100	3,800	1,100	1,000	4,200

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 the aeronautical flight research programs of the Flight Research Center. These instrumentation systems include general purpose tracking, telemetry, data handling, and communications systems, as well as special purpose optical equipment.

DEEP SPACE NETWORK
WORKLOAD



The sounding rocket program continues to be very active, with over three hundred launches last year, ranging from the smaller meteorological rockets to the larger Scout rockets. The majority of these sounding rocket launches are conducted at the Wallops Flight Center (WFC). This workload is expected to remain at approximately the same level in FY 1977. In addition to the continuing sounding rocket and aeronautical program activities, Wallops will provide specialized tracking, evaluation and calibration services for the GEOS-C and Seasat projects.

The Flight Research Center (FRC) operates the Aerodynamic Test Range, consisting of facilities at FRC and an 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. Various aircraft and lifting body research and technology projects are supported by the Aerodynamic Test Range. These efforts include the F-111, F-104, F-15, YF-12, and the 747 Shuttle carrier aircraft. Preparations are underway for support of the Shuttle Orbiter Approach and Landing Tests, which will be initiated at the Flight Research Center in late 1977.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate: The $300 thousand decrease in the current FY 1976 funding level from the previous submission is due primarily to deferral of depot level maintenance on radar systems at both WFC and FRC.

Transition Quarter Estimate: This $100 thousand decrease in the current estimate from the previous estimate is due primarily to minor changes in support requirements.

BASIS OF FY 1977 ESTIMATES:

The FY 1977 budget request covers the funding requirements for support of the sounding rocket launches and the Aerodynamic Test Range activities planned. In addition to the effect of escalation, the requirements increase to provide support associated with the initiation of the Shuttle Approach and Landing Tests at the Flight Research Center.

Communications Operations

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
26,038	27,900	26,000	7,000	6,500	26,000

OBJECTIVES AND STATUS:

NASA's global communications network (NASCOM) interconnects by means of leased voice and data circuits the tracking and data acquisition facilities in operational support of all flight projects. NASCOM also links together such facilities as launch areas, test sites, and mission control centers. The Goddard Space Flight Center operates the 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 key domestic and overseas locations.

To an increasing extent, the NASA flight projects are requiring the transfer of higher data rates between the mission control centers and the tracking sites because of the need for real time control of spacecraft and on-board experiments. In addition, there is a requirement to provide increasing amounts of experiment data more quickly to the users for analysis.

In order to meet these higher data transfer rate requirements, new communications technology making use of digital techniques and specially modified voice channels is being implemented into the NASCOM. These innovations allow for the transmission of a greater amount of data over the communication circuits. This technology will be expanded to all network facilities as rapidly as service can be obtained from the common carriers.

Based on technological advances permitting the transmission of higher data rates at reasonable cost, the "bent pipe" concept of sending data directly from a spacecraft, through a tracking station, to a mission or project control center, is becoming increasingly attractive. As a result, the trend will be toward more direct spacecraft-to-control center data transfer via high-speed communication links.

CHANGES FROM BUDGET ESTIMATES:

The reduction of $1.9 million in FY 1976 and $500 thousand in the Transition Quarter from the budget estimates reflects the closing of the Tananarive Station and some unforeseen communications rate reductions.

BASIS OF FY 1977 ESTIMATES:

The FY 1977 budget request for Communications Operations will provide the necessary funding for the circuits and services required to operate and maintain the NASCOM, including the various domestic and overseas facilities. Included are the funds required for communications support for the Shuttle Approach and Landing Tests and the provision of overseas wideband communications circuits for support of the Viking Mars missions and the Mariner Jupiter/Saturn (MJS 1977) missions.

Data Processing Operations

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
22,476	25,000	24,000	6,900	6,200	24,800

OBJECTIVES AND STATUS:

Information received in the form of tracking and telemetry data from the various spacecraft must be processed into a useable form for the day-to-day spacecraft operations and for analyzing the experiment data acquired by the spacecraft. This data processing function is performed for a wide variety of programs, which range from the small Explorer satellites to large and complex Solar and Astronomical Observatories and the Earth Resources Technology Satellites.

Tracking data are processed to provide orbital elements which are used to compute spacecraft positions. These functions are essential for the real time control of spacecraft, for determining when the spacecraft will be passing over the stations so data can be acquired, and for providing precise information that can be used by the scientific experimenters to determine where in the trajectory of the spacecraft the scientific measurements were made. Telemetry data must be processed to: (a) separate the information obtained from various scientific experiments aboard the spacecraft; (b) consolidate information from each experiment; (c) determine spacecraft attitude; and (d) correlate these measurements with the position data. Processed data are the primary product of the spacecraft missions, and it is through reductions and analyses of these data by the experimenters that the planned objectives are achieved.

In addition to the actual processing of the data, the upcoming projects require extensive pre-mission orbit studies, including spacecraft position and attitude predictions. Studies are also required to develop operational sequences and procedures to be used during the actual mission operations of these complex spacecraft.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate: The reduction of $1.0 million in the FY 1976 funding level resulted from launch schedule changes and the refinement of support requirements which made possible the deferral of manning increases and software effort for the operation of the centralized data processing facility located at the Goddard Space Flight Center.

Transition Quarter Estimate: The reduction of $700 thousand in the Transition Quarter funding level resulted from the deferral of contractor staffing and software effort for the operation of the data processing facility at the Goddard Space Flight Center.

BASIS OF FY 1977 ESTIMATES:

The FY 1977 budget estimate includes funds to process data from currently orbiting satellites, as well as data from the satellites scheduled to be launched during the period. The scientific requirements for the acquisition and processing of data from the older satellites are under continuing review, and support for older missions is terminated or curtailed as mission objectives are achieved or when the experiment data is no longer useful. These support adjustments are making possible the support of new satellites without major increases in the data processing capability.

The Image Data Processing Facility, initially established for the support of the first Earth Resources Technology Satellite (LANDSAT-1), now also supports the second LANDSAT spacecraft, which was successfully launched in January 1975. This facility is expected to continue operations through the next several years, supporting the current Earth Resources programs, and will be augmented to support approved upcoming missions that produce imagery data.

Software procurement activities have been initiated for support of space science and applications spacecraft such as the International Ultraviolet Explorer (IUE), the Heat Capacity Mapping Mission (HCMM), the International Sun-Earth Explorer-A (ISEE), Nimbus-G, and Seasat-A. These activities cover spacecraft control and related data processing requirements and require additional funding for FY 1977.

The data processing facility will be reconfigured in FY 1977 when the Telemetry On-Line Processing System (TELOPS) is phased in. This reconfiguration will result in the change from a tape-oriented process to an automated on-line electronic mass storage system. TELOPS will receive satellite data in digital form from the Network on NASCOM communication lines. This system will be able to store up to six months of telemetry data on-line, thus eliminating most of the tape handling operations within the data processing facility. Dual operation of the present system, plus TELOPS, will require additional funding until the new system is checked out and accepted.

BASIS OF FUND REQUIREMENTS:

Systems Implementation

The objectives of the NASA tracking and data systems implementation program are to maintain the existing ground support capability at a high level of proficiency and reliability in order to meet the aggregate support needs of the many and varied space missions, and to provide augmentation to this capability,

as necessary, to meet the special requirements of individual flight projects. These ground support systems consist of the tracking and communications networks, control centers, data processing facilities and aeronautics and sounding rocket instrumentation.

The systems implementation program encompasses the engineering design and procurement of the necessary equipment, subsystems and systems in response to the requirements of the various flight missions and other research projects. It also includes related documentation and development of initial computer programs, 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 necessary operational performance and reliability of network systems by providing for the replacement of obsolete and wornout equipment, the modification and augmentation of existing systems to maintain compatibility with changes in associated on-board spacecraft communications systems and to improve the utilization and efficiency of network systems.

Fiscal Year 1977 funds are required to continue the implementation of new capabilities, including those necessary for network system augmentation to meet the needs of the Mariner Jupiter/Saturn 1977, Pioneer Venus, and High Energy Astronomy Observatory missions. In addition, funds are required to complete the modification and augmentation of the data processing facilities for processing the imagery data for such missions as the Nimbus-G, Landsat-C, and Heat Capacity Mapping Missions.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Space flight tracking and data network	20,313	17,400	18,500	5,100	4,700	19,000
Deep space network	13,351	14,300	11,300	5,400	4,000	14,000
Aeronautics and sounding rocket support	2,700	2,700	2,300	700	700	2,600
Communications	3,160	3,000	3,000	800	800	3,900
Data processing	2,976	4,000	3,000	900	800	3,000
Total	42,500	41,400	38,100	12,900	11,000	42,500
Spaceflight Tracking and Data Network Systems Implementation						
	20,313	17,400	18,500	5,100	4,700	19,000

OBJECTIVES AND STATUS:

During FY 1977, the network will continue to support approximately forty spacecraft on an around-the-clock basis. These include many ongoing missions with highly complex tracking and data acquisition requirements, such as the Applications Technology Satellite 6, Landsat 1 and 2, the Geodynamic Experimental Ocean Satellite 3, Space Science Atmospheric Explorers 4 and 5, Nimbus G, and the Communications Technology Satellite. In addition to the ongoing missions, the network will provide support to a number of new missions. Among these are the High Energy Astronomy Observatory A, the International Ultraviolet Explorer, the Laser Geodynamic Satellite, and Landsat-C.

The Space Flight 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 multi-purpose tracking, command, and data acquisition support for all manned and unmanned earth orbital missions, and to meet new support requirements for spacecraft to be launched in the near future.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate: The FY 1976 funding level has been adjusted from the budget estimate by $1.1 million as a result of increased funding requirements for implementation of precision tracking lasers to support LAGEOS, the Laser Geodynamic Satellite.

Transition Quarter Estimate: The decrease of $400 thousand in the Transition Quarter funding level from the budget estimate reflects a reduction in the sustaining effort associated with the closure of the Tananarive station.

BASIS OF FY 1977 ESTIMATES:

Equipment modifications in the network are required in FY 1977 to maintain the required level of proficiency for support of a diverse and demanding workload and to assure the reliability of the network systems. Accordingly, funds are required for replacement of worn out systems with more reliable units, for equipment modifications to correct operational deficiencies, and for equipment to be used in operational control of the network. The funding requirements also provide for subsystem 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.

Necessary network system augmentations will be continued in FY 1977 to support preparations for the Shuttle first manned orbital flight planned for mid-1979. Implementation of equipment for monitoring

the Shuttle orbiter's approach and landing testing at the Flight Research Center will be completed. In addition, a 9-meter antenna will be relocated at the Merritt Island, Florida, station to permit coverage of Shuttle landings at the Kennedy Space Center, and systems compatible with the Space Shuttle Orbiter command systems will be installed in the network stations. Additional modifications will be initiated at the Merritt Island station to provide capabilities for compatibility testing of Space Shuttle payloads.

Several significant control center modifications at the Goddard Space Flight Center are also planned in FY 1977. The existing OSO/AE control center will be augmented to accommodate the Seasat on-board high data rate radar. Refurbishment of the Meteorological Data Handling System for support of Nimbus-G will be initiated in FY 1977. These refurbishments will include new command and control consoles, as well as telemetry data handling and display systems. In the Multi-Satellite Operations Control Center at Goddard Space Flight Center, the replacement of computer systems is planned. These computer systems are becoming obsolete, resulting in considerable maintenance and difficulty in obtaining spare parts.

Deep Space Network Systems Implementation

	1976		Transition Quarter		1977
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)			
13,351	14,300	11,300	5,400	4,000	14,000

OBJECTIVES AND STATUS:

The Deep Space Network Systems Implementation program provides for the procurement of equipment and integration services required in the network to support the ongoing planetary spacecraft missions and for network augmentations to support the upcoming approved planetary flight missions.

Communication with planetary spacecraft at extreme distances from earth requires very large antennas and extremely sensitive ground receiving systems. To assure mission success, these systems must operate at a high level of technology proficiency and reliability. Therefore, a continuing effort of replacement, modification and augmentation of the network systems is necessary. In addition, state-of-the-art improvements in telecommunications systems are incorporated in the network to maximize the scientific return from these missions.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate: A decrease of $3.0 million in the FY 1976 budget and $1.4 million in the Transition Quarter resulted from the deferral of the procurement of network systems for the Mariner Jupiter/Saturn 1977 (MJS) mission.

BASIS OF FY 1977 ESTIMATES:

During FY 1977, the Deep Space Network will continue to provide intensive support to ongoing planetary flight missions, as well as preparing for upcoming approved missions. The extended Viking, Pioneer 10 and Pioneer 11 missions, and the Helios 1 and B missions, will require equipment modifications to maximize the scientific data return. Critical mission events associated with the multi-spacecraft Viking mission, in particular, are dependend upon flawless ground system performance. These events include the Mars orbit insertion, lander descent and touchdown phase, and the operation of the scientific experiments on the surface of Mars.

An extremely high level of system reliability is necessary to support these missions and requires a continuing program of replacement and spares provisioning. Funds are required in FY 1977 for the replacement of failure-prone and obsolete components and to make the necessary system modifications to maximize the scientific return from these missions.

Preparations are also continuing for support of the dual Mariner missions to Jupiter and Saturn in 1977 (MJS '77) and the Pioneer multi-probe and orbiter missions to Venus in 1978.

For the MJS '77 mission, modifications to the command systems are necessary in order to provide the increased command capability required by the on-board spacecraft computer. The programs stored in the computer will be used not only to control the numerous spacecraft functions but also to change the telemetry data rate and content as variations in the mission profile occur.

Equipment modifications to the receiver systems are also required for the X-band telemetry capability on-board the MJS '77 spacecraft. The use of the X-band frequency along with a new telemetry coding system will provide the capability for transferring the large quantities of vital science and engineering data during the Jupiter and Saturn flyby phases of the mission. These flybys will occur at distances out to one and one half billion kilometers from Earth.

The MJS '77 mission, which includes plans for the spacecraft to perform close, precision flybys of the moons of the planets, requires an increase in space navigation accuracy. To obtain the improved accuracy special tracking, data handling and timing systems are needed. With these systems a new technique will be used whereby the spacecraft range and velocity will be simultaneously measured from two widely spaced tracking stations. The data obtained through this technique will provide a basis for improving space navigation accuracy.

FY 1977 funding requirements provide for continued implementation of these systems, initiated in prior years. Present emphasis is directed toward providing equipment at those stations needed for pre-launch testing with the spacecraft and for the launch and early cruise phases of the mission. FY 1977 funds will be used to provide the systems in the network for supporting the later cruise and Jupiter encounter phases of the mission.

Special equipment and modifications are required to support the Pioneer-Venus Orbiter and Multi-Probe missions. Simultaneous recovery of data from the five probes entering the Venus atmosphere requires additional receiving, recording and data handling capabilities in the network. The long duration Venus orbital operation, using dual frequency S and X-band transmitters, also requires modification of a Goldstone, California, 26-meter station to receive both frequencies.

Aeronautics and Sounding Rocket Support Systems Implementation

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
2,700	2,700	2,300	700	700	2,600

OBJECTIVES AND STATUS:

The aeronautics and sounding rocket programs are supported at the Wallops Flight Center in Virginia and and the Flight Research Center in California.

The aeronautics program support 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. More than 300 sounding rockets are launched from Wallops Island and remote sites around the world, carrying experiments in the fields of Aeronomy, Energetic Particles, Ionospheric Physics, Meteorology, and Solar Physics. Of particular interest is the current effort to measure the effect of aerosols on the protective layer of ozone in the upper atmosphere which filters out harmful solar radiation.

To provide instrumentation support to these programs, fixed and mobile ground support equipments are provided by Wallops. To maintain these equipments, spare and replacement parts are required, as well as some non-recoverable flight hardware such as on-board antennas and transponders. To meet specific test requirements, modifications and augmentations of selected telemetry, communications, tracking, command and data handling systems are required. In addition, the mobile equipment must be periodically refurbished and modified to meet remote site requirements such as the ongoing meteorological program in cooperation with several nations, including Argentina, Brazil, and Spain.

The aeronautical research and technology programs supported by the Flight Research Center (FRC) consist of high altitude and terminal area tests involving high performance aircraft and lifting bodies such as the F-111, YF-12, 747 Shuttle carrier aircraft, and various other aircraft and helicopters. Flight Research Center will also 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 BUDGET ESTIMATES:

FY 1976 Estimate: The decrease of $400 thousand in the FY 1976 funding level resulted from deferral of equipment replacements at Wallops Flight Center and the Flight Research Center.

BASIS OF FY 1977 ESTIMATES:

Funds are requested in FY 1977 to provide the sustaining equipment and modifications to support the sounding rocket and aeronautics program as described above.

Communications Systems Implementation

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
3,160	3,000	3,000	800	800	3,900

OBJECTIVES AND STATUS:

The objective of the Communications Systems Implementation efforts is to provide 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 1977 ESTIMATES:

The FY 1977 funding requirements provide for continued procurement of systems for increasing the amount of data that can be sent through communications circuits. As discussed in the communications operations area, specialized equipment is necessary for implementing digital techniques into the NASCOM network so that the higher data rates can be sent over these circuits. Funds are also included for wideband interface equipment which will be required in the "bent pipe" mode of operation.

Circuit monitoring and performance equipment is required for transmitting higher real time data rates from the Deep Space Network stations. This equipment will provide the capability for automatically detecting and isolating circuit problems and will permit rapid rerouting of circuits when problems arise. This capability is critical in meeting the increasing real time communications requirements for the planetary missions being supported by the Deep Space Network.

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.

Data Processing Systems Implementation

	1976		Transition Quarter		1977
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)			
2,976	4,000	3,000	900	800	3,000

OBJECTIVES AND STATUS:

The Data Processing Systems Implementation program provides for the procurement of equipment and related services to sustain the large computer complexes at the Goddard Space Flight Center (GSFC) which support both the operational and payload requirements of space missions. For operational support, these complexes determine spacecraft attitude and orbit and provide the capability for generating commands to the spacecraft and for knowing the status of on-board subsystems. In providing payload support, these complexes continually process the data from science and applications experiments for subsequent transfer to the experimenters.

Several significant activities in these areas are underway at GSFC. For the processing of digital data, a Telemetry On-Line Processing System (TELOPS) is under contract, and delivery is anticipated in early 1977. A major modification to the Image Processing Facility is underway to meet the accuracy and resolution requirements of future missions. Also, plans are underway to procure equipment to interface between the NASCOM terminal and the existing data processing facility to accommodate the wideband data transmission mode currently being implemented in the NASCOM Network.

CHANGES FROM BUDGET ESTIMATES:

FY 1976 Estimate: The decrease of $1.0 million in the FY 1976 estimate is due to a deferral in funding for equipment for the Image Processing Facility into FY 1977.

Transition Quarter Estimate: The decrease of $100 thousand in the Transition Quarter estimate is related to revised estimates for sustaining equipment during this period.

BASIS OF FY 1977 ESTIMATE:

The FY 1977 estimate includes funds to complete the modification of 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, including Landsat-C, Nimbus-G, and the Heat Capacity Mapping Mission (HCMM). Funds are also required for equipment to interface between the new Telemetry On-Line Processing System (TELOPS) and the existing computer processors at Goddard Space Flight Center.

During FY 1977, equipment will be procured for recording and formatting scanner data from HCMM. Special interface equipment will be installed between the NASCOM terminal and the Data Processing Facility to handle the digital data which will be transmitted by the NASCOM network. In addition, FY 1977 funds provide for routine support of the computer complex. This effort includes spares provisioning, replacement of old analog tape decks, and procurement of special devices to monitor the photographic quality of the products produced in the Image Processing Facility.

Advanced Systems

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
9,300	9,200	9,200	2,300	2,300	8,700

OBJECTIVES AND STATUS:

The objective of the Tracking and Data Acquisition (TDA) Advanced Systems program is to conduct studies and developments in tracking and data acquisition systems and techniques. These studies and developments are necessary to: (1) provide new and improved network and data processing capabilities to meet near-term mission requirements; and (2) improve the cost effectiveness and reliability of TDA support for the mix of space flight missions. This latter objective includes spacecraft and ground system trade-off studies aimed at optimizing space-to-ground telecommunications links and overall operational support planning.

BASIS OF FY 1977 ESTIMATES:

Effort will continue on studies and developments in the areas of tracking and ground-based navigation for planetary missions. New and more efficient tracking techniques using two station tracking and Very Long Baseline Interferometry (VLBI) will be investigated. Development of these techniques is needed to reduce existing sources of errors in spacecraft tracking. For example, the Mariner Jupiter/Saturn '77 missions include plans for the spacecraft to fly by and take pictures of Io, a satellite of Jupiter, which will be about 735 million kilometers from Earth. The navigation accuracy required for this event is roughly comparable to navigating an airplane from Washington, DC, with sufficient accuracy to intercept a speeding, supersonic aircraft over Paris with a miss distance of less than 3 meters.

Such requirements push the state-of-the-art in many fields of technology. As a further example, ultra-stable ground clocks are needed which gain or lose only a thousandth of a second in 10,000 years. These clocks, which are located on different continents, must be synchronized to a common standard with an error of no greater than 10 millionths of a second.

Radio telecommunications techniques will continue to be developed in FY 1977 to provide the increased capability needed to support future spacecraft command and data acquisition requirements. Future planetary missions will use data rates in excess of 40 kilobits per second from the vicinity of Saturn, approximately 1.5 billion kilometers away. Studies and developments will continue on ways to minimize the effect of planetary atmospheres and space-charged particles on deep space communications. Data acquisition with our large aperture antennas will be further improved by the development of techniques for the arraying of existing antennas at higher frequencies and the development of low radio-noise elements coupled with receivers having improved sensitivities. To date, our continuing work in the development of extremely sensitive receivers has yielded significant improvements in data collection rates at planetary distances.

Future earth orbital missions with new high resolution sensors for monitoring the land, the sea, and the environment, require an order of magnitude improvement in the rate at which data must be acquired and handled. Effort is required on millimeter wave ground antenna feed systems, telemetry receivers, and wideband recording systems as well as on network station operating techniques for handling these high data rates.

Work will continue on techniques for centralizing the control and monitoring of tracking and data acquisition support operations, both at the stations and their respective network control centers. This development is aimed at improved efficiency and effectiveness in the utilization of the overall network system.

Studies and development will also be conducted on data handling systems and techniques to meet the increasing data requirements for real time mission control. The studies will be concerned particularly with high-rate, on-line data handling, storage, and retrieval. Techniques to be considered include

the cross connecting and multiple use of minicomputers and the development of standardized software and operating procedures to better support the total mix of future missions in a cost effective manner.

Tracking and Data Relay Satellite System

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
3,600	---	---	---	---	---

OBJECTIVES AND STATUS:

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.

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 elimination of many of the ground stations in the present Spaceflight Tracking and Data Network 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.

NASA has initiated a competitive two-phase procurement approach to acquire TDRSS service. Phase I involved the award of two study contracts for definitive system design and technical and cost proposals. The FY 1975 funding level shown was for the Phase I contracts. Phase II will involve the competitive selection of a single contractor for final design, implementation and operation.

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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1977 ESTIMATES

BUDGET SUMMARY

OFFICE OF INDUSTRY AFFAIRS AND TECHNOLOGY UTILIZATION

TECHNOLOGY UTILIZATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Industrial applications	2,414	3,220	3,145	850	850	3,245
Technology applications	2,373	3,025	3,500	950	950	3,640
Program control and evaluation	713	755	855	200	200	1,015
Total	5,500	7,000	7,500	2,000	2,000	7,900
Distribution of Program Amount by Installation:						
Johnson Spacecraft Center	388	795	566	100	100	600
John F. Kennedy Space Center	40	100	110	25	25	100
Marshall Space Flight Center	58	405	408	100	100	400
National Space Technology Laboratories	---	---	53	---	---	50
Goddard Space Flight Center	350	565	547	100	100	350
NASA Pasadena Office/Jet Propulsion Laboratory	473	780	694	200	200	520
Wallops Flight Center	15	---	15	---	---	15
Ames Research Center	438	680	718	150	150	680
Langley Research Center	455	640	645	125	125	440
Lewis Research Center	80	300	250	50	50	250
Headquarters	3,203	2,735	3,494	1,150	1,150	4,495
Total	5,500	7,000	7,500	2,000	2,000	7,900

RD 12-1

OFFICE OF INDUSTRY AFFAIRS
AND TECHNOLOGY UTILIZATION

TECHNOLOGY UTILIZATION PROGRAM

PROGRAM OBJECTIVES AND JUSTIFICATION:

The NASA Technology Utilization program is a structured and planned system, designed to encourage the application and use of aerospace-developed technology in the nation's industrial and public sector communities. A spectrum of transfer and dissemination mechanisms is employed by NASA to effectively interact with potential users in the non-aerospace community.

During Fiscal Year 1977, the Technology Utilization program plans to further expand its "outreach" efforts initiated in FY 1976. Program outreach would increase the number of industrialized urban areas and regions served nationwide through the addition of more Industrial Applications Center territorial representatives. Further development of those outreach efforts in FY 1977 would substantially increase the probability of technology transfer and aid in the fuller coverage of technological need existing in practically every corner of the nation.

Additional problem-solving opportunities are anticipated in FY 1977, including biomedical, transportation, and public safety projects in applications engineering. These efforts will greatly facilitate and strengthen the application and adaptation of aerospace technologies to important public sector needs. In addition, NASA plans to undertake new efforts in such critical areas as computer-aided manufacturing techniques in support of increased productivity and agriculture. NASA experience in technology transfer indicates that the continuation and expansion of these outreach efforts during FY 1977 will effectively enable broader use and application of aerospace-developed technology and know-how in the U.S. industrial and public sectors.

CHANGES FROM BUDGET ESTIMATES:

Additional funds in the amount of $500,000 were made available to the Technology Utilization program in FY 1976 as a result of FY 1976 Congressional authorization action. This enabled us to initiate a dissemination center in the southeastern region of the U.S., and new regional representatives in San Francisco, Dallas, Cleveland, Buffalo, and New York City.

BASIS OF FY 1977 ESTIMATES

Industrial Applications

The effort in FY 1977 will focus on the expanded distribution of new technology to a broader industrial community, with specific attention given to small business firms. Distribution and packaging improvements as well as modifications in technical presentation are planned, in order to reach a broader segment of the U.S. industrial community. Special emphasis will also be placed on increasing technology-user relevance through use of trade and professional journals.

During Fiscal Year 1977, NASA plans to further augment and extend its Industrial Applications Centers "outreach program". Additional IAC territorial representatives will be located in urban industrial centers not now covered; and the effort to increase awareness of the availability of NASA technology for use by private and public sector users will be increased through the use of journals, periodicals and exhibits.

The expansion and improvements in effectiveness of the IAC's and the new technology publications program, and increased awareness by the user community are necessary to permit the widespread dissemination and use of this national technical resource throughout the economy.

Technology Applications

Effective application of aeronautics and space developments to significant public sector needs, such as medicine, environment, transportation, and public safety, often requires extensive problem definition and technology demonstrations with user participation. These efforts constitute the Technology Applications program which is directed toward solution of technological problems identified by user organizations at the federal, state, and local levels.

Multidisciplinary application teams are employed by NASA to assist user organizations in problem definition and technology matching activities. In addition to the existing teams which now cover the fields of medicine, transportation, and public safety, NASA proposes during FY 1977 to develop new teams in manufacturing processing and in agriculture. The manufacturing processing team will focus on the use of computer-aided manufacturing to increase productivity, and the agriculture team will address both the production and processing of agricultural products.

Technology applications projects to assist in the demonstration of the applicability of NASA technology will emphasize biomedical, transportation, and public safety efforts. Such projects, selected on a priority basis, are conducted at NASA field installations to adapt, modify, or otherwise re-engineer existing

aerospace technology to meet performance requirements defined by public sector user organizations. Prototype solutions are also used to stimulate industrial manufacturing and commercialization interest, thus providing increased probability for nationwide availability. Candidate projects are fully coordinated with, and sometimes co-funded by, user agencies, and efforts are made to insure early industrial participation in order to provide a stimulus for subsequent industrial commercialization.

Program Control and Evaluation

Program evaluation studies will be continued with particular emphasis in FY 1977 on IAC outreach efforts to expand geographical coverage and penetration of nationwide industrial users. These evaluation efforts will determine the extent and effectiveness of marketing activities attendant with IAC programs. Additionally, analyses of specific economic benefits resulting from the secondary application of NASA technology in selected fields, such as health care, will be initiated in FY 1977.

At the same time, NASA plans to improve its methods for documenting specific evidence of technology transfer, and expand its efforts to disseminate such information to the media and general public. Programmatic changes are ofttimes required as a result of such evaluation studies and analyses. Such factors as industrial receptivity, time lag, and technological relevance are analyzed on a case-by-case basis to determine the relative impact and effectiveness of NASA's technology transfer efforts.

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 advance design related to facilities planned for future authorization.

The funds requested for 1977 provide for the continuation of prior years' endeavors in meeting the facilities requirements for the space shuttle program; rehabilitation, modification and minor construction of facilities to maintain, upgrade and improve the usefulness of the NASA physical plant; and facility planning and design activities.

Space shuttle facility requirements in FY 1977 are less than amounts requested and approved in the last few years. The projects and amounts reflected in the budget estimate are time sensitive in order to meet the specific milestones established for the first horizontal and manned orbital flights. In addition to space shuttle facilities projects, the estimates include funds for facility modifications to provide for processing space shuttle and spacelab payloads.

The program for FY 1977 also includes initial funding for a large aeronautical facility, the construction of a National Transonic Facility at the Langley Research Center. Requirements for this and other aeronautical research and technology facilities are outlined in detail in the enclosed justifications.

Other projects included in the FY 1977 program are in support of scientific investigations in space, space research and technology, and supporting activities.

The Rehabilitation and Modification of Facilities program continues to meet the objectives of preserving and enhancing the capabilities and usefulness of existing facilities, and to ensure continued safe, economical and efficient use of the NASA physical plant. The Minor Construction program provides the means to accomplish smaller facility projects which for the most part are to accommodate technical requirements stemming from research, development, test and similar activities.

Funds requested for Facility Planning and Design cover advance planning and design requirements for potential future projects, master planning, facilities studies, and engineering reports and studies.

The request for FY 1977 is $124,020,000, an increase of $41,890,000 over the amount appropriated for FY 1976. Outlays are estimated to be $125,700,000 in FY 1977, an increase of $10,900,000 over the estimate for FY 1976.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

CONSTRUCTION OF FACILITIES

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, [$82,130,000] *$124,080,000*, to remain available for obligation until September 30, [1978] *1979: 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 obligation thereof, 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, $10,750,000, to remain available for obligation until September 30, 1979.] (*42 U.S.C. 2451, et seq.; Department of Housing and Urban Development—Independent Agencies Appropriation Act, 1976; additional authorizing legislation to be proposed.*)

CONSTRUCTION OF FACILITIES

Program and Financing (in thousands of dollars)

Identification code 27-00-0107-0-1-999	Budget plan (amounts for construction of facilities authority programmed)				Costs and obligations			
	1975 actual	1976 estimate	TQ estimate	1977 estimate	1975 actual	1976 estimate	TQ estimate	1977 estimate
Program by activities:								
Direct program:								
1. Space flight	77,185	47,220		39,875	35,945	67,500	20,000	64,000
2. Scientific investigations in space	18,770			8,720	8,043	10,451	1,700	6,900
3. Space applications					17			
4. Space research and technology	660			680	1,089	34		
5. Aeronautical research and technology	9,745	4,635		28,950	5,496	515	200	100
6. Supporting activities	36,295	30,275	10,750	45,845	35,923	9,500	2,000	18,400
						38,000	9,600	43,300
Total direct program costs, funded	142,655	82,130	10,750	124,020	86,514	126,000	34,000	132,700
Reimbursable program:								
9. Supporting activities	400	3,000				3,400		
Total reimbursable program costs, funded	400	3,000				3,400		
Total program costs, funded	143,055				86,514	129,400	34,000	132,700
Change in selected resources (undelivered orders)					16,370	22,600	−24,200	−10,700
10 Total	143,055	85,130	10,750	124,020	102,884	152,000	9,800	122,000
Financing:								
11 Receipts and reimbursements from: Federal funds	−400	−3,000			−400	−3,000		
21 Unobligated balance available, start of period: For completion of prior period budget plans:								
Direct					−16,734	−118,429	−49,959	−50,909
Reimbursable						−433		
24 Unobligated balance available, end of period: For completion of prior period budget plans:								
Direct					116,429	49,959	50,909	52,429
Reimbursable					400			
25 Unobligated balance lapsing					76			
Budget authority	142,655	82,130	10,750	124,020	142,655	82,130	10,750	124,020
Budget authority:								
40 Appropriation	140,155	82,130	10,750	124,020	140,155	82,130	10,750	124,020
42 Transferred from other accounts	2,500				2,500			
43 Appropriation (adjusted)	142,655	82,130	10,750	124,020	142,655	82,130	10,750	124,020
Relation of obligations to outlays:								
71 Obligations incurred, net					102,484	149,000	9,800	122,500
72 Obligated balance, start of period					91,432	108,609	142,809	121,409
74 Obligated balance, end of period					−108,609	−142,809	−121,409	−118,709
90 Outlays					85,307	114,800	31,200	125,200

None.—Reconciliation of budget plan to obligations

	1975 actual	1976 estimate	TQ estimate	1977 estimate
Total budget plan	117,065	85,130	10,750	124,020
Deduct portion of budget plan to be obligated in subsequent periods	−67,615	−35,130	−1,250	−30,000
Add obligations of prior period budget plans	58,497	102,000	250	28,500
Total obligations	107,881	152,000	9,800	122,500

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

SUMMARY OF THE BUDGET PLAN BY LOCATION
(In Dollars)

Location	FY 1975	FY 1976	Transition Quarter	FY 1977
Ames Research Center	3,660,000	2,695,000	---	4,490,000
Flight Research Center	---	---	---	750,000
Goddard Space Flight Center	2,110,000	---	---	---
Jet Propulsion Laboratory	8,820,000	---	---	---
Johnson Space Center	935,000	---	---	2,800,000
Kennedy Space Center	---	---	---	2,805,000
Langley Research Center	3,505,000	1,940,000	---	6,185,000
Lewis Research Center	3,240,000	---	---	2,170,000
Marshall Space Flight Center	4,060,000	---	---	---
Wallops Flight Center	1,370,000	---	---	---
Large Aeronautical Facility	---	---	---	25,000,000
Various Locations	7,470,000	---	---	---
Space Shuttle Facilities	77,185,000	47,220,000	---	39,825,000
Space Shuttle Payload Facilities	---	---	---	4,340,000
Rehabilitation and Modification	14,900,000	16,000,000	7,000,000	17,875,000
Minor Construction	4,500,000	5,000,000	1,250,000	5,125,000
Facility Planning and Design	10,900,000	9,275,000	2,500,000	12,655,000
Total Plan	142,655,000	82,130,000	10,750,000	124,020,000

	FY 1975	FY 1976	Transition Quarter	FY 1977
SUMMARY OF THE BUDGET PLAN BY COGNIZANT OFFICE				
Office of Space Flight	78,120,000	47,220,000	---	43,755,000
Office of Space Science	22,400,000	---	---	3,570,000
Office of Aeronautics and Space Technology	10,405,000	4,635,000	---	30,850,000
Office of Tracking and Data Acquisition	1,430,000	---	---	750,000
Office of Center Operations	---	---	---	9,440,000
NASA Comptroller	30,300,000	30,275,000	10,750,000	35,655,000
Total Plan	142,655,000	82,130,000	10,750,000	124,020,000

SUMMARY OF BUDGET PLAN BY SUBFUNCTION

Code No.	Title				
253	Space Flight	77,185	47,220	---	39,825
254	Space Science, Applications and Technology	19,430	---	---	9,400
255	Supporting Space Activities	36,295	30,275	10,750	45,845
(250)	Subtotal, General Science, Space and Technology	132,910	77,495	10,750	95,070
405	Air Transportation	9,745	4,635	---	28,950
	Total	142,655	82,130	10,750	124,020

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

BUDGET PLAN BY LOCATION AND PROJECT

Cognizant Office	Subfunction Code	Installation and Project	FY 1975	FY 1976	Transition Quarter	FY 1977	Page No.
			(In Thousands of Dollars)				
		Ames Research Center	3,660	2,695	---	4,490	
AST	254	Modification for high enthalpy entry facility.	---	---	---	1,220	CF 1-1
AST	405	Modification of flight simulator for advanced aircraft.....	---	---	---	1,730	CF 1-8
Cntr Ops	255	Construction of supply support facility.....	---	---	---	1,540	CF 1-14
AST	405	Modification of 11 by 11-foot transonic wind tunnel.....	---	2,695	---	---	
AST	405	Addition to flight and guidance simulation laboratory.....	3,660	---	---	---	
		Flight Research Center	---	---	---	750	
TDA	255	Construction of addition to flight control facility.....	---	---	---	750	CF 2-1
		Goddard Space Flight Center	2,110	---	---	---	
SS	255	Rehabilitation and modification of science and applications laboratories.....	890	---	---	---	
SS	255	Modifications for fire protection and safety..	1,220	---	---	---	

Cognizant Office	Subfunction Code	Installation and Project	FY 1975	FY 1976	Transition Quarter	FY 1977	Page No.
			(In Thousands of Dollars)				
		Jet Propulsion Laboratory	8,820	---	---	---	
SS	255	Acquisition of land	150	---	---	---	
SS	254	Addition to systems development laboratory (SDL)	4,880	---	---	---	
SS	254	Addition for integrated systems testing facility	3,790	---	---	---	
		Lyndon B. Johnson Space Center	935	---	---	2,800	
SS	254	Construction of addition to lunar sample curatorial facility	---	---	---	2,800	CF 3-1
SF	255	Modification of water supply system	935	---	---	---	
		John F. Kennedy Space Center	---	---	---	2,805	
SF	254	Construction of airlock to spin test facility.	---	---	---	360	CF 4-1
Cntr Ops	255	Modifications for utility control system	---	---	---	2,445	CF 4-8
		Langley Research Center	3,505	1,940	---	6,185	
AST	405	Construction of addition for aeroelastic model laboratory	---	---	---	730	CF 5-1
Cntr Ops	255	Construction of data reduction center annex	---	---	---	2,970	CF 5-6
Cntr Ops	255	Construction of refuse-fired steam generating facility	---	---	---	2,485	CF 5-12
AST	405	Addition for composite model and metal finishing shops	---	1,940	---	---	

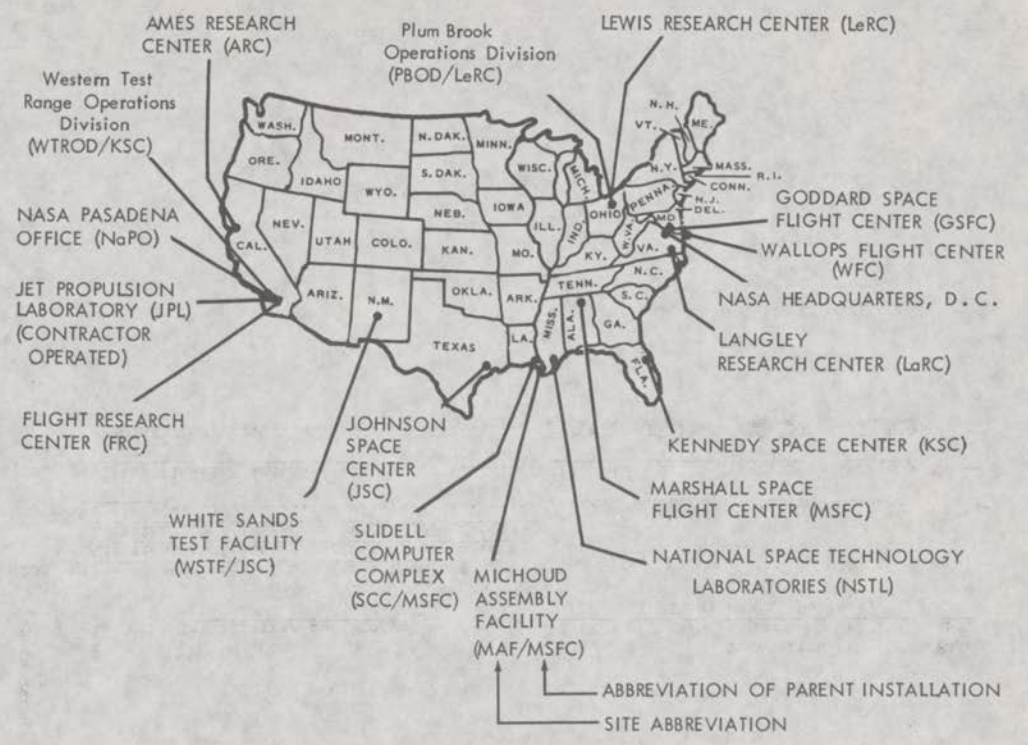
Cognizant Office	Subfunction Code	Installation and Project	FY 1975	FY 1976	Transition Quarter	FY 1977	Page No.
			(In Thousands of Dollars)				
AST	405	Modification of 6,000 p.s.i. air storage system	515	---	---	---	
AST	405	Rehabilitation of 16-foot transonic wind tunnel	2,990	---	---	---	
		Lewis Research Center	3,240	---	---	2,170	
AST	254	Modification of refrigeration system, electric propulsion laboratory	---	---	---	680	CF 6-1
AST	405	Rehabilitation of combustion air drying system, engine research building	---	---	---	1,490	CF 6-6
AST	405	Modification of propulsion systems laboratory.	2,580	---	---	---	
AST	254	Modification of rocket engine test facility...	660	---	---	---	
		Marshall Space Flight Center	4,060	---	---	---	
SS	254	Construction of X-ray telescope facility	4,060	---	---	---	
		Wallops Flight Center	1,370	---	---	---	
SS	255	Modification of beach protection system	1,370	---	---	---	
		Large Aeronautical Facility as Follows:	---	---	---	25,000	
AST	405	Construction of national transonic facility (LaRC)	---	---	---	25,000	CF 7-1

Cognizant Office	Subfunction Code	Installation and Project	FY 1975	FY 1976	Transition Quarter	FY 1977	Page No.
			(In Thousands of Dollars)				
		Various Locations	7,470	---	---	---	
SS	254	Construction of infrared telescope facility, Mauna Kea, Hawaii	6,040	---	---	---	
TDA	255	Modifications for fire protection and safety at various tracking stations	1,430	---	---	---	
		Space Shuttle Facilities at Various Locations as Follows:	77,185	47,220	---	39,825	
SF	253	Construction of orbiter processing facility (KSC)	13,380	8,160	---	3,750	CF 8-4
SF	253	Modifications to launch complex 39 (KSC)	35,355	13,110	---	19,855	CF 8-12
SF	253	Modifications for solid rocket booster processing facilities (KSC)	---	5,240	---	9,700	CF 8-20
SF	253	Construction of shuttle/carrier aircraft mating facilities (FRC, Palmdale, Calif., and KSC)	1,500	3,890	---	2,050	CF 8-31
SF	253	Construction of orbiter approach and landing test facilities (FRC, Calif. and Palmdale, Calif.)	2,940	1,680	---	---	
SF	253	Modifications for crew training facilities (JSC)	420	830	---	780	CF 8-36
SF	253	Rehabilitation and modification of shuttle facilities, at various locations	---	---	---	1,760	CF 8-43
SF	253	Modification of manufacturing and final assembly facilities for external tanks, (MAF)	---	---	---	1,930	CF 8-48

Cognizant Office	Subfunction Code	Installation and Project	FY 1975	FY 1976	Transition Quarter	FY 1977	Page No.
			(In Thousands of Dollars)				
SF	253	Modifications for hypergolic checkout and refurbishment facilities (KSC).....	---	6,940	---	---	
SF	253	Modifications for launch equipment test facilities (KSC).....	---	1,960	---	---	
SF	253	Modification of the vibration and acoustic test facility (JSC).....	410	2,410	---	---	
SF	253	Modifications for solid rocket booster component manufacturing and assembly facilities (location to be designated).....	---	3,000	---	---	
SF	253	Construction of orbiter landing facilities (KSC).....	15,880	---	---	---	
SF	253	Modifications for dynamic test facilities (MSFC; Downey, Calif.).....	3,920	---	---	---	
SF	253	Construction of materials test facility (WSTF).....	790	---	---	---	
SF	253	Modifications for solid rocket booster structural test facilities (MSFC).....	2,590	---	---	---	
		Space Shuttle Payload Facilities at Various Locations as Follows:	---	---	---	4,340	
SF	254	Modifications to operations and checkout building for spacelab (KSC).....	---	---	---	3,570	CF 9-1
SS	254	Modifications and addition for shuttle payload development (GSFC).....	---	---	---	770	CF 9-7
COMPT	255	Rehabilitation and Modification of Facilities at Various Locations, Not in Excess of $500,000 Per Project.....	14,900	16,000	7,000	17,875	CF 10-1

[illegible]	Subfunction Code	Installation and Project	FY 1975	FY 1976	Transition Quarter	FY 1977	Page No.
			(In Thousands of Dollars)				
COMPT	255	Minor Construction of New Facilities and Additions to Existing Facilities at Various Locations, Not in Excess of $250,000 Per Project	4,500	5,000	1,250	5,125	CF 11-1
COMPT	255	Facility Planning and Design	10,900	9,275	2,500	12,655	CF 12-1
		TOTAL PLAN	142,655	82,130	10,750	124,020	

LOCATION OF NASA MAJOR AND COMPONENT INSTALLATIONS



SUM 12

RECORDED VALUE OF CAPITAL-TYPE PROPERTY
IN-HOUSE AND CONTRACTOR HELD
AS OF JUNE 30, 1975
(Thousands of Dollars)

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	196,541	6,166	---	205,635	116,810	16,938	337,383
ARC-Moffett Field, CA	2,928	196,541	6,166	---	205,635	108,824	16,938	331,397
Various Locations(b)	---	---	---	---	---	5,986	---	5,986
Flight Research Center	---	9,853	3,037	---	12,890	63,823	1,459	78,172
FRC-Edwards, CA	---	9,853	3,037	---	12,890	60,031	1,459	74,380
Various Locations(b)	---	---	---	---	---	3,792	---	3,792
Goddard Space Flight Center	1,661	91,830	58,670	172	152,333	549,170	14,647	716,150
GSFC-Greenbelt, MD	1,308	75,869	16,065	172	93,414	197,928	8,920	300,262
Tracking Stations (Networks)	353	15,960	42,560	---	58,873	279,283	5,727	343,883
Various Locations(b)	---	1	45	---	46	71,959	---	72,005
Jet Propulsion Laboratory	1,067	71,754	66,999	530	140,350	218,625	14,938	373,913
JPL-Pasadena, CA	1,067	59,836	7,756	385	68,844	132,138	14,938	215,920
Deep Space Network	---	12,118	59,243	145	71,506	86,487	---	157,993
Johnson Space Center	9,036	189,215	57,854	151	256,256	612,243	30,664	899,163
JSC-Houston, TX	5,466	155,470	32,340	63	193,539	324,473	30,664	548,676
White Sands Test Facility, WSTF-Las Cruces, NM	---	8,767	20,289	---	29,056	33,718	---	62,774
Various Locations(b)	3,570	24,978	5,025	88	33,661	254,052	---	287,713
Kennedy Space Center	71,345	297,723	310,931	---	679,999	589,556	23,622	1,293,177
KSC-FL	71,345	297,723	310,931	---	679,999	229,893	23,052	932,944
Western Test Range Operations Division, WTROD-Lompoc, CA	---	---	---	---	---	4,543	570	5,113
Various Locations(b)	---	---	---	---	---	355,120	---	355,120
Langley Research Center	116	132,810	155,400	---	288,326	169,363	45,694	503,383
LaRC-Hampton, VA	110	117,406	155,375	---	272,891	131,531	45,694	450,116
Various Locations(b)	6	15,404	25	---	15,435	37,812	---	53,247
Lewis Research Center	3,661	206,375	74,588	178	284,802	123,300	12,064	420,166
LeRC-Cleveland, OH	316	121,158	55,642	139	177,255	84,747	11,587	273,589
Plum Brook Operations Division, PBOD-Sandusky, OH	3,345	85,217	18,946	---	107,508	9,492	477	117,477
Various Locations(b)	---	---	---	39	39	29,061	---	29,100
Marshall Space Flight Center	7,368	197,558	109,156	---	314,282	476,360	24,570	815,412
MSFC-Huntsville, AL	---	118,769	54,541	---	173,310	245,716	9,775	428,801
Michoud Assembly Facility, MAF-New Orleans, LA	7,305	66,294	27,068	---	100,867	45,409	---	146,276
Slidell Computer Complex, SCC-Slidell, LA	63	4,518	879	---	5,460	22,345	723	28,528
Various Locations(b)	---	7,977	26,668	---	34,645	163,090	14,072	211,807
National Space Technology Laboratories	18,703	69,902	190,515	---	279,120	40,901	---	320,021
NSTL-Bay St. Louis, MS								
Wallops Flight Center	1,161	24,029	48,999	---	74,189	50,045	2,577	126,811
WFC-Wallops Island, VA	1,161	24,029	48,999	---	74,189	48,434	2,577	125,200
Various Locations(b)	---	---	---	---	---	1,611	---	1,611
NASA Headquarters	---	---	---	---	---	32,155	---	32,155
Washington, DC	---	---	---	---	---	1,760	---	1,760
Various Locations(b)	---	---	---	---	---	30,395	---	30,395
GRAND TOTAL	117,246	1,487,590	1,082,315	1,031	2,688,182	3,060,521	187,173	5,935,886

(a) Includes Contractor-Held Special Test Equipment (569,445).
(b) Includes Capital Type Property in Possession of Contractors at Various Locations.

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NOTES CONCERNING THE JUSTIFICATION FORMAT

The Construction of Facilities budget estimate format for individual projects is much the same as it has been in the past several years. However, certain modifications have been incorporated in an effort to improve the clarity and usefulness of the data presented. These are:

a. FY 1976 AND PRIOR YEARS FUNDING - Under this entry, for both planning and design, and construction, two lines are shown:

(1) Specific CoF funding - to reflect the specific application to this project of any CoF resources during the last five budget years.

(2) Other affiliated funding - to reflect any other prior year funding (CoF or other) applied to the facility with which this project is associated.

It is believed that this approach is more meaningful because the great bulk of the CoF projects involve modifications or additions to existing facilities. The distinction made in the data as now presented permits a ready appraisal of the resources more specifically related to the present considerations as distinguished from those involved in earlier work for other purposes. This data has been rounded to the nearest $1,000.

b. LIST OF RELATED GRAPHICS - This heading has been added to identify additional material accompanying each project justification.

c. OTHER EQUIPMENT SUMMARY - This heading has been added to isolate and clearly set out this important facet of each project. In the past this material has been provided within the body of the documentation and its segregation will serve to facilitate its identify.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE: Modification for High Enthalpy Entry Facility

INSTALLATION: Ames Research Center

FY 1977 CoF ESTIMATE: $1,220,000

LOCATION OF PROJECT: Moffett Field, Santa Clara County, California

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Technology

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	134,000	3,575,000	3,709,000
Other affiliated funding	---	2,026,000	2,026,000
Total	134,000	5,601,000	5,735,000

SUMMARY PURPOSE AND SCOPE:

This project provides for the construction of a 160 megawatt (MW) constricted arc facility in an existing test bay of Building N-238 at the Ames Research Center. The facility will perform the tests required to design and qualify the heat shield thermal protection systems of probes for entry into planetary atmospheres. Also included in the project are the fabrication and installation of the constricted arc heater and modification of the existing power supply, gas, water and vacuum systems.

PROJECT JUSTIFICATION:

Although the "state-of-the-art" of thermal protection during atmospheric entry has matured considerably over the last several years since the Apollo missions, new missions requiring survival for even more hos-

tile entry environments are currently being considered for the 1980-1990 time period. These missions include the entry of probes into the atmospheres of the outer planets, advanced maneuverable missile systems of high accuracy, the return of surface samples from Mars, and possibly of the disposal of toxic wastes in space and the attendant problem of safety in event of a mission abort. Each of these missions can be designed to involve a low thermal protection system risk provided that an appropriate factor of safety is used to account for uncertainties in the understanding of the fundamental phenomena that have as yet not been adequately explored by experiments. With an appropriate high enthalpy entry simulation facility, these prudent factors of safety can be reduced thereby increasing the efficiency of the mission or reducing the risk associated with the thermal protection system.

At the very high enthalpy entry conditions for the missions mentioned above, the mechanisms of thermal protection are considerably different than experienced for Apollo or current Intercontinental Ballistics Missiles (ICBM) reentries. For the outer planet probe mission, the heating is largely radiative from the hot gas shock layer surrounding the vehicle. The critical heat protection mechanisms of ablation-product absorption and ablating-surface reflection cannot currently be verified experimentally because no facility exists capable of simulating this heating environment. For the same reason, the potentially destructive phenomena of particulate removal and thermal stress inducted spallation caused by the high heating and high surface shear cannot be experimentally tested at present.

There are no known ablation facilities existing, either in the U.S. or abroad, that can achieve the required enthalpy simulation for probe entry into the atmospheres of the outer planets. The successful exploration of the atmosphere of any one of the outer planets (Jupiter, Saturn, or Uranus) by probe will require that new heat shield technology be developed prior to the design of the probe. At present, due to lack of experimental testing capability, the prudent factor of safety for a shallow entry (i.e., 7.5^{o} entry angle) into the atmosphere of Jupiter is currently about 35% in consideration of all present uncertainties. The thermal protection system under these conditions will amount to about one-half of the total probe system weight. The ratio between the thermal protection system weight and the science payload weight is then about 4. Thus, it is obviously important to have a firm determination of the required heat shield weight and not to use any larger factor of safety than necessary. With a full ground-based verification of the ablation mechanisms, it is felt that the factor of safety could be reduced to about 20% thereby permitting the potential of a 50% increase in science payload weight. Alternatively, the risk associated with a steeper entry (i.e., 15^{o} entry angle) could be reduced allowing greater mission flexibility in the selection of entry conditions (e.g., permitting a daylight entry at high solar elevation angles which is not possible with a shallow entry angle).

Therefore, the construction of the high enthalpy entry simulation facility at Ames Research Center, together with the existing lower energy facilities, will permit the evaluation of thermal protection system materials for advanced missions of the next decade in a timely manner, thereby allowing an increase in the efficiency of those missions and a reduction in technology risk.

PROJECT DESCRIPTION:

This project will provide for the fabrication and installation of a 160 MW constricted arc heater and nozzle in an exiscing test bay in Building N-238. The arc heater will be water-cooled and consist of components such as an anode, cathode, gas inlet, constrictor, and nozzle. The arc heater will be capable of producing the conditions required for simulating entry into planetary environment.

The existing 110 MW DC power supply will be increased to 160 MW by the addition of six power modules. Additional cooling and distribution shall be added to provide the power densities for the longer durations (10 to 15 seconds) required by the 160 MW arc heater.

This project will also include the modification of the existing gas, water, and vacuum systems of Building N-238 to meet the start up and operating needs of the arc heater. Necessary structures for the arc heater and the support systems and a safety enclosure will be provided.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				905,000
Electrical (inside 5' line)	LS	---	---	100,000
Support systems	LS	---	---	225,000
Utilities (outside 5' line)	LS	---	---	580,000
Equipment				315,000
Provision of arc heater and nozzle	LS	---	---	315,000
Fallout Shelter (not feasible)	---	---	---	---
Total				1,220,000

LIST OF RELATED GRAPHICS:

Location Plan
Single Line Drawing
Sketch of Constricted Arc Heater

OTHER EQUIPMENT SUMMARY:

No other collateral or noncollateral equipment is involved.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

There are no foreseen future funding requirements necessary to complete this project.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE:	Modification of Flight Simulator for Advanced Aircraft
INSTALLATION:	Ames Research Center
	FY 1977 CoF ESTIMATE: $1,730,000

LOCATION OF PROJECT: Moffett Field, Santa Clara County, California

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Technology

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	333,000	3,860,000	4,193,000
Other affiliated funding	204,000	16,916,000	17,120,000
Total	537,000	20,776,000	21,313,000

SUMMARY PURPOSE AND SCOPE:

This project will increase the operational efficiency of the Flight Simulator for Advanced Aircraft by making more simulator time available for the investigators. It will allow a complete check-out of a simulation before the project occupies the simulator itself, and thus will increase the efficiency of both the use of the facility and the time of the investigators.

The proposed interchangeable module/platform system will allow "off-board" alterations to be made to the simulator cockpit, thereby reducing the time required for cockpit changeover between tests. Additionally, the cockpit module can be initially operated in the "test stand", allowing a complete check-out of the computer program and computer cockpit inter-ties before the project occupies the motion generator of the Flight Simulator for Advanced Aircraft.

PROJECT JUSTIFICATION:

The Flight Simulator for Advanced Aircraft (FSAA) is the most advanced simulator in existence. It is presently scheduled two shifts per day for the foreseeable future on "man-in-the-loop" simulation projects. These projects include certification criteria investigations in cooperation with the Federal Aviation Administration, and support of military aircraft programs for the Department of Defense. A most important use is the support of NASA research aircraft projects. The FSAA has been used in this manner to support the "Augmentor Wing Jet STOL Research Aircraft" and is still in current use in design support of the "Tilt Rotor Research Aircraft" and will continue to be used on this project through its flight test program. Scheduled projects in support of NASA research aircraft include the "Rotor Systems Research Aircraft". The work to be performed includes investigation of concept simulations, through design support simulations, to flight test support. It has also been used to support a space flight project, simulation of Space Shuttle landing.

The FSAA system is designed to accommodate frequent changes in the simulated vehicle. All cockpit hardware is connected by plugs and, for example, a control stick can conveniently be exchanged for a "column wheel" control. Entire instrument panels can be built up "off-board" and made ready to install between projects. As a further illustration of flexibility, a ceiling mounted throttle lever system can be interchanged for a conventional floor mounted throttle.

Ability to make these cockpit change overs was designed into the original FSAA simulator. The success of the simulator has produced an unanticipated heavy demand. In the past year, 27 different simulation projects have used the FSAA. Thus, the change-over time between projects becomes even more significant than originally estimated. The time required for cockpit change-over and the time spent in completion of the simulation computer cockpit check-out is not available for data taking.

It is anticipated that the proposed interchangeable module platform system will increase the FSAA data-taking time by 20 "shift-weeks" per year. This will allow an average of an additional five simulation projects to be conducted on the FSAA each year. The inherent flexibility of these changes will also permit new simulation equipment to be readily installed as it becomes available.

Because the FSAA facility is currently fully utilized, prospective programs are carefully screened to insure that the problems being investigated require its unique capabilities. As a consequence, most of the scheduled programs are ones in which the high fidelity lateral motion cues are critical to the piloted assessment. Deferment of such programs can leave unanswered questions which cannot be fully resolved in other facilities. In the case of hardware development programs, these unknowns can be extremely costly and time consuming to correct, and potentially hazardous if left until initial flight evaluations are made.

PROJECT DESCRIPTION:

The Flight Simulator for Advanced Aircraft (FSAA) located in Bldg. N-243 will be modified to provide a quick module change and/or readily changeable platform system. Included with this modification will be a new frame mounting technique for improved vibration isolation. Three new platforms will be provided. These platforms can be interchangeable for major changes but normal or minor modifications can be made by exchanging modules. Each of the platforms will be able to accommodate a pilot, co-pilot, flight engineer and observer. The platform will be fabricated aluminum with a number of hard points to accommodate almost any cab/module configuration. A ground check-out station and modification fixture will be included. One of the platforms not in use on the simulator will be mounted on this fixture for module change and computer program check-out. The last platform will be used for long term configurations and advanced visual display studies. Equipment modules to outfit two cabs (instrumentation, consoles, seats and control loaders) will be provided.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				50,000
Building and structure modifications	LS	---	---	50,000
Equipment				1,680,000
Platform and shell	EA	3	185,000	555,000
Modifications to gimbal system	LS	---	---	205,000
Platform-handling equipment	LS	---	---	70,000
Cockpit equipment	LS	---	---	595,000
Computer communications equipment	LS	---	---	255,000
Fallout Shelter (not feasible)	---	---	---	---
Total				1,730,000

LIST OF RELATED GRAPHICS

Location Plan
Perspective and platform and module views

OTHER EQUIPMENT SUMMARY

The existing noncollateral computer equipment and instrumentation valued at $3.9 million will be used with this facility. The existing collateral equipment to be used with this facility is approximately $2.7 million and includes an existing simulator, and the dedicated test equipment, communications equipment, data acquisition system, and control equipment.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

There are no presently known future requirements to complete this project.

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CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE:	Construction of Supply Support Facility
INSTALLATION:	Ames Research Center
FY 1977 CoF ESTIMATE:	$1,540,000

LOCATION OF PROJECT: Moffett Field, Santa Clara County, California

COGNIZANT HEADQUARTERS OFFICE: Office of Center Operations

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	95,000	---	95,000
Other affiliated funding	---	---	---
Total	95,000	---	95,000

SUMMARY PURPOSE AND SCOPE:

This project provides for the construction of a separate "warehouse" type facility in an undeveloped area of Ames Research Center. The facility is intended to support the warehousing, shipping and receiving functions. The project will include special storage spaces for items such as flammable goods, hazardous chemicals, goods which require refrigeration, etc. Overhead hoists, loading docks and office space are also to be included.

Due to the proposed facility being sited in an underdeveloped area at the Center, it will be necessary to provide supporting utilities and access roads as part of the project. The area selected for the siting of the project is in accordance with the ARC master plan.

PROJECT JUSTIFICATION:

Successful performance of the mission of the Ames Research Center, or any major research center, is dependent in a large way on responsive support of the needs, both institutional and technical, of the research complement. Adequate storage and supply support is an essential element of this responsiveness. Since 1940, Ames Research Center has grown from a few buildings to a present replacement value of over $660,000,000, consisting largely of research equipment and facilities. In 1952, it was necessary to move the increased warehousing, shipping, and receiving functions from the Electrical Services Building to a 45,000-square foot (4,180 sq. m.) area under the 40-by 80-Foot Wind Tunnel, which currently provides 26,000 square feet (2,415 sq. m.) for stores issue, 7,000 square feet (650 sq. m.) for receiving, and 12,000 square feet (1,115 sq. m.) of miscellaneous storage. It was realized that the working environment under this wind tunnel was marginal at best, but then there was the possibility that the amount of testing in the wind tunnel would decrease. The tunnel use has increased, in fact, multiple shifts are forecast indefinitely. In addition the noise levels under this existing wind tunnel have increased to the range of 90 to 120 decibels depending on the tunnel test conditions. Studies have shown that this noise not only interferes with communications, but is also potentially detrimental to the health of the personnel involved (e.g., loss of hearing, nervous problems, etc.). At the present time, the Center is also using 80,000 square feet (7,432 sq. m.) of closed storage space located at Camp Parks, Pleasanton, California, 37 miles from Ames; 60,000 square feet (5,574 sq. m.) of open, fenced, hard standing storage at Camp Parks; 17,000 square feet (1,579 sq. m.) of open, fenced, hard standing storage area at the Ames Research Center; and 12,000 square feet (1,115 sq. m.) of closed temporary storage. The off-site locations required added manpower and funds to function at an acceptable level, the open storage has limited use especially in winter, and other temporary covered storage arrangements at the Center are unsatisfactory. This project will permit reducing the existing closed storage space at Camp Parks in half for use as long term storage, and remove it from day to day logistics operations. The U.S. Navy at Moffett Field cannot provide storage area for Ames' use.

It is not possible to provide efficient and responsive supply and storage support for the Center's operations with the present "patchwork" arrangement. For example, research missions aboard Center airborne science aircraft have been delayed because of the need to call in off-duty warehousing support personnel to make the 74 mile round trip to Camp Parks for aircraft repair parts. Frequently, it may also be necessary to send an aircraft mechanic to Camp Parks to provide the technical judgment as to the suitability of substitute parts. While this kind of problem is not necessarily typical or an everyday occurence, it represents the potential for adversely affecting research programs, e.g., the ability of airborne science researchers to make their observations within ideal time windows.

As a more general matter, it is not possible to respond adequately to the research needs of the Center under the present arrangement. For example, Services and Supply Division personnel estimate that Center usage justifies at least 1,000 additional items of stock inventory, but the lack of sufficient space in

the issue room precludes the stocking of these items. Thus, such items must be purchased on an individual basis, with resultant additional procurement workload and loss of quantity purchase advantages. Incoming shipments of bulk purchases which must be consigned to other storage locations (local or Camp Parks) many times requiring handling twice on receipt; usually this is repeated when the stored material is used, and this second handling is often piece-by-piece instead of in bulk. Also, the present facility will not accommodate necessary expansion of the existing refrigerated storage space, thus incurring similar problems for phototechnology supplies and other materials that must be stored under refrigeration.

The existing receiving facility has a single entry door, thus shippers with incoming materials have to "queue up" to unload. This frequently forces outgoing vehicles for on-Center deliveries to wait until the situation has cleared. Under these circumstances, it is impossible to conduct a routine and orderly receipt and dispatch of materials. There is no other realistic alternative to the present unsuitable arrangement than to provide for this facility.

PROJECT DESCRIPTION:

The proposed facility will consist of a new one-story, high bay structure containing a gross area of 80,000 square feet (7,432 sq. m.) with about 48,600 square feet (4,515 sq. m.) of warehousing functions, 15,000 square feet (1,394 sq. m.) of shipping and receiving functions and 12,000 square feet (1,115 sq. m.) of stock issuing functions. The net office space included in the project is 4,400 square feet (409 sq. m.) for Property Management Supply Branch and contract employees. Construction is a steel frame and roof system with prefinished sheet metal exterior walls and heavy duty concrete floor on grade. Shops and storage areas will be heated. Offices will be heated and air-conditioned. Also included will be ramps, loading docks, and cranes for shipping and receiving.

The proposed site is presently undeveloped. Extension of all necessary utilities and roadways are included and sized to serve presently proposed construction and future expansion. Parking facilities and minimal site improvements to the structure are to be included.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				1,540,000
Utilities outside 5' line	LS	---	185,000	185,000
Site work	LS	---	180,000	180,000
Architectural/structural	SF	80,000	10.50	840,000
Mechanical/plumbing	SF	80,000	2.87	230,000
Electrical	SF	80,000	1.31	105,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				1,540,000

LIST OF RELATED GRAPHICS:

Location Plan
Perspective
Single Line Drawing

OTHER EQUIPMENT SUMMARY:

There are no additional known collateral or noncollateral equipment required to make this facility operational.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

As presently planned, there are no foreseen future funding requirements necessary to complete this project.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE:	Construction of Addition to Flight Control Facility
INSTALLATION:	Flight Research Center
	FY 1977 CoF ESTIMATE: $750,000

LOCATION OF PROJECT: Edwards, Kern County, California

COGNIZANT HEADQUARTERS OFFICE: Office of Tracking and Data Acquisition

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	53,000	---	53,000
Other affiliated funding	---	3,567,000	3,567,000
Total	53,000	3,567,000	3,620,000

SUMMARY PURPOSE AND SCOPE:

The purpose of the project is to enhance the operational efficiency, safety of flight monitoring and flight data processing of the Flight (Mission) Control Facilities utilized by the Flight Research Center (FRC) for aeronautical flight research. These objectives will be obtained from this project by providing the needed space to collocate the necessary members of the flight control team and their supporting equipment in a central control area with ready access to flight display boards, other technical specialists involved and computer data outputs.

To make space available to accommodate this centralized control area, an addition will be made to the south side of Building 4800 extending the floor area of the second and third floors by approximately 8,410 square feet (781 square meters). The increased space will accommodate a new and larger control area plus

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provide the necessary space for the tracking data computer, telemetry ground station, television acquistion and recording, and random and high frequency data analysis items of equipment.

PROJECT JUSTIFICATION:

The Flight Research Center (FRC) currently conducts flight research of some of the most important research aircraft in the world today. With the continuing drive for increased efficiency and cost effectiveness in the area of flight research, the typical research aircraft today is more highly instrumented with more sophisticated sensors and data acquisition systems than ever before. Correspondingly, the ground control station necessary to process the flight data has grown more complex, extensive, and sophisticated. FRC has kept pace with demands by continual updating and improvements of its Flight Control Facility. However, the lack of physical space has now become a most serious constraining factor.

Because of the lack of space, the flight controllers (people who must react quickly, efficiently, and in a coordinated fashion, especially in emergency situations) must be located in separate areas. By shortening the lines of communication, and providing better working space with access to the appropriate computer data outputs, the overall efficiency, hence the safety of flight, will be significantly enhanced.

The most valuable output of flight research is data. Real time data displays are utilized by flight controllers to monitor the progress of any particular flight in order to assure accomplishment of mission objectives in a safe and efficient manner. Post-flight data processing gives engineers and scientists the information they require to perform the analyses that provide the real benefits from flight research. In recent years, data display and data processing have been identified as key factors in limiting the FRC's attempts to make flight programs more efficient, hence, less costly.

Processed data is required to be displayed on the ground during flight so that ground controllers can assure Flight Safety, assist in setting up the exact flight conditions to obtain the required research data, assure that all instrumentation and aircraft systems are functioning properly for the experiment, and take the appropriate action when unanticipated events occur. This eliminates the need for additional flights to obtain data missed in prior flights. Real time data is also required to assure flight safety in proceeding from one test point to another.

Rapid post-flight data processing is required so that the project engineer can assess from the research team the status of flight results and plan the details of the next flight. Typical time required to process data after flight should not exceed two working shifts, but it is not possible for FRC to meet this goal on major projects at present. Failure to achieve this "turn around" generates pressures that could result in either delayed flight schedules or flying without proper assessment of data from the previous flight.

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These problems were recognized and corrective action taken, new ground systems are coming into being at FRC, but now the major limiting factor in obtaining maximum efficiency is physical floor space restrictions.

This facility will be used to support most of the future aeronautical flight research programs as well as the Space Shuttle Approach and Landing Test (ALT) and Secondary Landing Site (SLS) tests. A partial list of these programs is:

YF-12
Highly Maneuverable Aircraft Technology (HiMAT)
F-8 Digital Fly-By-Wire
Tilt Rotor Research Aircraft
Drones for Aerodynamics and Structural Testing
Fuel Conservation Flight Experiments

The situation which has evolved is not surprising since this control room has not undergone any basic change in size or layout since about 1960. High technology aircraft such as the F-15, F-8 (Digital Fly-By-Wire), and YF-12 require more systems monitoring and display facilities to conduct safe and efficient flights. While the technical equipment has been approved, funded, and are being provided, interior installation in the present space will result in a condition which is operationally unacceptable to FRC until the proposed project is approved and completed.

PROJECT DESCRIPTION:

This proposed project will provide for a two-story addition, approximately 8,410 square feet (781 square meters), to the south side of Building 4800, extending the existing areas of the second and third floors. The structure will be constructed with steel supporting columns and beams, steel floor decking and insulated metal roof. The exterior wall will be of steel studs with a stucco surface esthetically matching the existing building. The second floor will provide offices for the Range Systems, Range Operations, and Tracking and Communications Telemetry. A meeting room, rest rooms, halls and stairways are also included with this project. The addition to the third floor will provide for the Division's operating equipment in connection with the existing operations area. The new space will be occupied by the telemetry ground station equipment, the flight control room, a technical viewing room and a stairway.

The existing third floor area of Building 4800 will be reconfigured, allowing safe structural loading conditions on the floor, with adequate spacing and clearances of equipment and the installation of a tape storage room.

A separate electrical and air conditioning system will be installed which will allow operation of the facility from an independent on-site generated power source. In this mode the facility will be able to operate for critical flight test programs without risk of mission failure due to commercial power outages.

All necessary utilities and adequate fire protection system are included with this project.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				735,000
Architectural and structural	SF	8,410	44.00	370,000
Mechanical	SF	8,410	32.00	270,000
Electrical	SF	8,410	11.30	95,000
Equipment				15,000
750 KVA transformer	EA	1	15,000	15,000
Fallout Shelter (not feasible)	---	---	---	---
Total				750,000

LIST OF RELATED GRAPHICS:

Location Plan
Single Line Drawing - Second Floor
Single Line Drawing - Third Floor

OTHER EQUIPMENT SUMMARY:

Existing noncollateral equipment such as consoles, computer, peripheral equipment valued at about $1,700,000 will be used with this facility. There are no known additional collateral equipment required to be used with this 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 1977 ESTIMATES

PROJECT TITLE:	Construction of Addition to Lunar Sample Curatorial Facility
INSTALLATION:	Lyndon B. Johnson Space Center
	FY 1977 CoF ESTIMATE: $2,800,000

LOCATION OF PROJECT: Houston, Harris County, Texas

COGNIZANT HEADQUARTERS OFFICE: Office of Space Science

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	391,000	---	391,000
Other affiliated funding	55,000	1,946,000	2,001,000
Total	446,000	1,946,000	2,392,000

SUMMARY PURPOSE AND SCOPE:

This project provides for a 15,000-square foot (1,394m^2) addition to the existing Lunar Sample Curatorial Facility (Building 31) at Johnson Space Center (JSC) to allow safe, secure, and effective storage, inspection, study, and scientific analysis of lunar samples.

PROJECT JUSTIFICATION:

The Apollo Program brought 842 pounds (382 kg) of lunar material to earth. The lunar samples are a tangible result of a great national effort and constitute an invaluable scientific resource that will require study into the indefinite future. These invaluable scientific resources cannot be replaced since

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there are no current plans to return to the moon. It is imperative then that this material be stored and processed in a facility that provides maximum protection from potential hazards, such as intense storms, theft, and vandalism. Equally important is the fact that the experience and technology gained since 1969 in procedures for cataloging, handling, and studying lunar samples now permit a better definition of requirements for building a facility that will meet the need for lunar sample curation into the future.

Because of the concern and risks involved in housing all the lunar sample material at one location, NASA has recently taken measures to alleviate this situation. After considerable study of alternative sites remote from JSC, a facility located at Brooks Air Force Base, San Antonio, Texas, was selected as the optimum place for storing a representative sample (20 to 30 percent) of the variety of materials in the collection. The required modifications to prepare the facility to receive and store the material safely and effectively is nearing completion, and it is expected that the lunar samples will be stored at this remote site early in CY 1976.

It has been recognized, however, that the major portion of curatorial activities will remain at Johnson Space Center, where the specialized curatorial expertise to carry out the vital research exists. It has also been recognized that the existing facilities at JSC should be improved to afford a more effective environment for the preservation and processing of the samples. Based on recent studies, it is considered that present facilities at JSC do not provide the fullest protection of lunar samples from natural and man-made hazards. For example, Building 31 affords very little protection from heavy storms, especially those involving tornadoes, floods, and hurricanes, or from excessive building and ground shock waves, sabotage, or vandalism. The hazard from hurricane surge tides increases as local ground subsidence in the JSC area continues. The crowded and limited capabilities available, as well as the concern for improved protection, have led NASA to disperse large portions of the samples in various locations at Johnson Space Center. These samples should be returned to the principal working collection for inspection by the curatorial personnel and for ready accessibility to the scientists. This project provides for a secure storage vault and the associated laboratory facilities for these essential scientific activities.

NASA has considered the use of the Lunar Receiving Laboratory, Building 37, to accommodate the curatorial functions. This alternative proved less economical and less effective than the facilities proposed in this project. The Lunar Receiving Laboratory was constructed to provide for the quarantine of returned lunar materials and astronauts. At that time, the main concern was to ensure that potential life forms from the moon would not be allowed to contaminate the earth. The facility was not configured to handle the present scope of curatorial activities. Generally, the Lunar Receiving Laboratory included features such as sophisticated cabinetry for biospecimen exposure to lunar material, systems for physical and chemical analysis, low-level vacuum systems for sample processing, incineration of all waste, crew living quarters, and emergency medical facilities. Also, it was designed for post-mission contamination control and not for long-term secure sample storage and inventory management. Most of these unique systems were removed several years ago and are now being used by another Government agency. This removed equipment,

although unique for quarantine purposes, was different from the cabinetry and mode of operation required in today's curatorial activity. Using this facility would require major modifications and a new addition with a properly positioned vault to protect against hazards. The modifications and addition would cost more than this FY 1977 project.

For this reason, and because nearly all curatorial activities and equipment are now located in Building 31, it has been determined that the continued use of the present curatorial facility, with the proposed addition, is the best and most effective solution to meeting the critical needs of the lunar curatorial functions.

The lunar material has been cataloged into nearly 46,000 samples, which are being studied by approximately 150 principal investigators and 1,000 other scientists. The quantity of lunar samples and the number of interested scientists are much greater than originally anticipated. There are currently no available laboratories which permit visiting scientists to examine pristine lunar samples. To the extent that visiting scientists are allowed to examine samples, the regular activities of the curatorial processing laboratories are hindered because both operations require the same amount of space and the same number of cabinets. There is presently no clean, secure laboratory to which a scientist can come and perform special experiments that would require large amounts of pristine material or a large fraction of a unique sample. Such facilities are required and needed whenever transfer of the subject materials to the scientist's own laboratory would involve unacceptable risks.

This project is required to provide safe secure storage and handling of the great number of lunar samples and for proper scientific characterization of these samples.

PROJECT DESCRIPTION:

This project provides for the construction of an approximately 15,000-square foot (1,394m^2) addition to the existing lunar sample curatorial facility at JSC. The two-story structure will be 61.5 feet by 115 feet (18.7m by 35.1m) with a 21-foot by 18-foot (6.4m by 5.5m) two-story connecting section. A 1,968 (net)-square foot (183m^2) ultraclean and highly secure vault for storing lunar samples is included. It will be located on the second floor, at an adequate elevation to protect the samples from potential flood damage. Processing, experiment, and simulation laboratories; data storage areas; and other support areas will also be provided.

Local and remote audible/visual alarms will be installed, and the necessary utility systems will be extended from an existing utility tunnel.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				2,800,000
Site preparation and utilities	LS	---	---	335,000
Structural and architectural (including vault)	LS	---	---	1,165,000
Mechanical systems	LS	---	---	995,000
Electrical systems	LS	---	---	270,000
Sprinkler system	LS	---	---	35,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				2,800,000

LIST OF RELATED GRAPHICS:

Location Plan
Building 31 Perspective
Building 31 Floor Plan

OTHER EQUIPMENT SUMMARY:

An estimated $295,000 in R&D funds for new noncollateral equipment such as lunar sample storage and processing cabinets, tables, benches, closed-circuit television, and analyzers are required to make the facility operational. Existing storage and processing cabinets and miscellaneous laboratory furniture and equipment valued at $370,000 will be relocated in the new addition.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

It is presently estimated that no future CoF funding requirements will be necessary to complete this project.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE: Construction of Airlock to Spin Test Facility

INSTALLATION: John F. Kennedy Space Center

FY 1977 CoF ESTIMATE: $360,000

LOCATION OF PROJECT: Cape Canaveral Air Force Station, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	26,000	---	26,000
Other affiliated funding	23,000	750,000	773,000
Total	49,000	750,000	799,000

SUMMARY PURPOSE AND SCOPE:

The purpose of this project is to provide an addition to the Spin Test Facility (STF) for use as an airlock to the Spin Test Bay. This 2,065-square foot (192 square meters) addition is required to provide space in which preliminary operations for the third stage/spacecraft can be accomplished in a clean environment without compromising the clean environment of the Spin Test Bay. The preliminary operations to be accomplished in the airlock include unloading the third stage/spacecraft-handling can from its transporter, cleaning and handling of Delta fairings, storage and cleaning spacecraft ground servicing equipment, and placement of the assembly in the "spacecraft-handling can" and loading onto its transporter.

PROJECT JUSTIFICATION:

The Spin Test Facility (STF), built in 1966, is the only facility having a spin test capability at Kennedy Space Center, Eastern Test Range. Spin test is the rotation of a space vehicle to ascertain its dynamic balance. Since other facilities at the launch site are overcrowded, the STF is being utilized for fueling and checkout in addition to spin test. The 2,065-square foot (192 square meters) addition is required to provide an additional clean area for preliminary operations without compromising the clean area of the Spin Test Bay and to alleviate its crowded condition.

Present operations require that all third stage/spacecraft components be brought into the high bay (Spin Test Bay), removed from their shipping containers, checked out, fueled, and placed into spacecraft-handling cans prior to opening the high bay doors. All excess equipment such as shipping containers, fuel-loading carts, and fairings are stored inside the high bay while check-out operations are proceeding. This excess equipment compromises high bay cleanliness and encroaches on work space needed for spin testing. thereby tending to cause a safety hazard.

The airlock will permit the movement of excess equipment in and out of the high bay as dictated by operational requirements without compromising the integrity of the high bay environment and operations. Moreover, the effective utilization of the facility will be greatly increased by not interrupting the high bay activities which will provide greater assurance that adequate and timely support for the launch schedule will be realized.

Since this is the only facility having spin test capability, it will be used for unmanned spacecraft such as the following: (1) International Sun Earth Explorer Satellite, (2) ESRO/Maritime Communications Satellite, (3) AEROSAT/Aircraft Navigation Satellite, (4) Japan/Communications Satellite, and (5) Japan/Broadcast Satellite.

PROJECT DESCRIPTION:

This project provides the construction of a 35 ft. x 50 ft. x 45 ft. high (11 m x 15 m x 14 m) airlock structure as an addition to the east side of the Spin Test Building (Building No. 67900). The structure is a blast-proof, narrow high bay type requiring reinforced columns and four levels of reinforced concrete beams to support wall construction and to tie the building together longitudinally. The project also includes air conditioning, provision of a fire protection system, installation of interior and exterior doors, installation of a compressed air and gaseous nitrogen system, and the provision of lighting and hoist system.

Other special requirements include a class 100,000 interior, the installation of explosion proof electrical devices, and a ventilating system having final filtration efficiency of 99.9% based on 0.3 micron particle size.

The building addition also provides for a personnel airlock entry and exit room of 117 square feet (11 square meters), and a mechanical and electrical room having 198 square feet (18 square meters).

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				281,000
Site work	LS	---	---	27,000
Architectural/structural	SF	2,065	61.00	126,000
Mechanical	SF	2,065	35.35	73,000
Electrical	SF	2,065	26.63	55,000
Special Construction Features				79,000
Hoist	LS	---	---	18,000
Airlock doors	LS	---	---	57,000
Central vacuum cleaner	LS	---	---	4,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				360,000

LIST OF RELATED GRAPHICS:

Location Plan
Perspective Drawing
Floor Plan

OTHER EQUIPMENT SUMMARY:

No additional equipment is required to complete this project.

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 1977 ESTIMATES

PROJECT TITLE: Modifications for Utility Control System

INSTALLATION: John F. Kennedy Space Center

FY 1977 CoF ESTIMATE: $2,445,000

LOCATION OF PROJECT: Merritt Island, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	250,000	310,000	560,000
Other affiliated funding	90,000	1,315,000	1,405,000
Total	340,000	1,625,000	1,965,000

SUMMARY PURPOSE AND SCOPE:

This project is a continuation and extension of the Utilities Control System previously funded under prior year programs and being installed in the Kennedy Space Center Industrial Area. The purpose of this project is to install the Utilities Control System in facilities in the Vehicle Assembly Building (VAB) area and Launch Complex 39, Pad "A" area to reduce costs and increase efficiency in the operation and maintenance in this portion of the Center's utility systems both during the phase down of activities prior to and through the operations phase of the Shuttle program. Such reduced costs will be made possible by installing sensing and control devices on the heating, ventilation, and air conditioning subsystems, and the subsystems of high temperature hot water, potable water, sewage treatment, fire alarm, and 60Hz electrical power to and within 51 facilities, in addition to monitoring and controlling utility sensing and

control devices being installed on subsystems in 22 new and modified facilities for the Shuttle program. The centralized monitor and control of various subsystems parameters will provide increased safety, conserve energy resources, and improve pollution control, thus contributing to better management of resources, and savings of personnel.

PROJECT JUSTIFICATION:

This is the third increment of a project initiated in CY 1974, to retain and improve the support capabilities in facilities necessary for KSC's long range launch mission role through the Shuttle program. The monitoring and control of utility heating, ventilation and air conditioning subsystems, and the subsystems of high temperature hot water, potable water, sewage treatment, fire alarm, and 60Hz electrical power by automation will achieve a significant reduction in manpower for operations now performed manually in a large number of facilities required to support the launches at Complex 39. Savings in the Utility Conservation Program will be achieved, the mission of support operations and task performance of maintenance and operations personnel will be enhanced and greater responsiveness to potential problems through early warnings of out-of-limit conditions of systems will be possible as a result of remote monitoring and control.

The Utility Control Systems complements the Launch Processing System. The Utility Control System will monitor and control subsystems, through automation, that provide basic services such as heating, ventilation and air conditioning for personnel and equipment, potable water, fire detection and protection, sewage treatment for personnel and electrical power for machinery and equipment in systems which indirectly support the processing and launching of Shuttle payloads and vehicles. The Launch Processing System will monitor and control those subsystems directly supporting the processing and launching of Shuttle payloads and vehicles.

The Utility Control System must be operationally ready by October, 1978, to support the launch site operations for first manned orbital flight. To meet this schedule, the work must start early in CY 1977, since modifications will require approximately 15 months for completion and checkout. Integration with the existing Utility Control System and with the Shuttle facilities will require approximately four months. For these reasons, this project must be included in the FY 1977 program.

This project schedules the purchase of the same type of equipment as the Shuttle Launch Processing System (LPS) to take advantage of the LPS equipment being operational one year prior to UCS utilization, insuring both hardware and software compatability and operability. In addition, system problems will have been solved and documented, and common maintenance and personnel training will be provided. The scope of this project represents the minimum facilities and subsystems necessary to allow operators at centralized control consoles to efficiently and cost-effectively monitor and control the various utility subsystems to support the initial launch capability at Launch Complex 39.

Automation will allow testing of utility systems on an end-to-end basis with significantly fewer personnel than previously achieved by manual means. This will permit faster identification of system defects than that obtained now by periodic preventive maintenance roving field personnel, enabling immediate shutdown or corrective action before major damage occurs. It will also provide operational flexibility because of the capability to change system configurations by preplanned software (program) inputs.

The implementation of this project is expected to result in identifiable manpower, energy and transportation savings. The potential manpower cost savings associated with this project, scheduled to begin in FY 1978, are as follows:

Approximately 35 electrical and 10 mechanical personnel at $23,000/year at present, escalated at 6% to the midpoint of the first operational year (April 1979), is about $27,000/year and equals a savings of about $1,215,000 the first year.

Energy consumption savings include both the base load and peak demand periods as follows:

A. Electrical Energy Savings - 18,000,000 KWH are presently used. This multiplied by the estimated savings of 6% is 1,080,000 KWH. This times the estimated operational year (April 1979) cost of $.039/KWH equals a savings of about $42,000 the first year.

B. Electrical Demand Savings - This project includes a feature permitting the reduction of kilowatt demand charges. This is estimated at about $35,000 the first year. This is based upon a savings of about 583,000 KWH and a demand peak savings of 6,880 KWH at $1.75/KWH projected to April 1979 at an escalation of 15%/year.

Transportation cost savings resulting from the reduction in "roving" preventive maintenance and operations personnel is as follows:

It is estimated that the 45 people no longer needed would otherwise have traveled approximately 4,000 miles per month in the discharge of their duties. It is estimated that the monthly charge for pickup vehicles in FY 1977 will be $70.00 and the charge for mileage will be $0.08 per mile. This represents a savings of $390.00 per month or $4,680 per year. Projected to April 1979 at an escalation of 6% per year, the estimated savings will be about $5,000 the first year.

Based upon the total cost of $2,445,000 and the identified potential cost savings of $1,297,000 the first year, the "payback" period is about 1.88 years for this project.

PROJECT DESCRIPTION:

This project provides sensors and controls in various utility subsystems connected to central computing equipment via the communications cable system. The HVAC subsystem has requirements for 1,362 signals in 25 facilities to be monitored and controlled, including air handler status, compressor-motor currents, chiller and pump status and water temperatures.

The high temperature hot water subsystem has requirements for 72 signals in one facility to be monitored and controlled, including temperatures and flow rates. The potable water subsystem has requirements for 110 signals in 6 facilities to be monitored and controlled, including water pressures, storage tank levels and pump status. The sewage treatment subsystem has requirements for 127 signals from 7 sewage treatment plants and 11 lift stations, including pump status, flow rates, chlorine residue, PH analyser and air flow. The fire alarm subsystem has requirements for 888 signals in 36 facilities, including fire and smoke detectors and sprinkler flow indicators. The 60 Hz electrical power subsystem has requirements for 1,861 signals from 34 facilities, including current and voltages of transformers in substations, status of circuit breakers, and remote control of automatic transfer switches.

Remote units will also be installed in 13 facilities to collect signals from a given area and transmit them to the centrally located computer equipment. The data processing equipment supporting the monitor and control functions consists of telemetry equipment, appropriate mass storage devices, required peripherals, centrally located computer equipment with operator consoles and Cathode Ray Tube (CRT) displays. The earlier existing Monitor and Control Station will be relocated and integrated into a combined centrally located operations station in the LC 39 area.

This Utility Control System will interface with the Launch Processing System on a computer-to-computer level for exchange of information.

The related graphics indicate the facilities and subsystems for which sensors and controls will be installed under this project. In addition, the Utility Control System will monitor and control sensors and controls in facilities constructed and modified under the Shuttle program.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				1,408,000
HVAC subsystem	LS	---	---	387,000
HTHW subsystem	LS	---	---	21,000
Potable water subsystem	LS	---	---	53,000
Sewage treatment subsystem	LS	---	---	116,000
Fire alarm subsystem	LS	---	---	110,000
60 Hz power subsystem	LS	---	---	721,000
Equipment				1,037,000
Remote units	LS	---	---	394,000
Monitor and control station	LS	---	---	414,000
Relocation of Phase I monitor and control station	LS	---	---	55,000
Utilities/USC system checkout	LS	---	---	174,000
Fallout Shelter (not feasible)	LS	---	---	---
Total				2,445,000

LIST OF RELATED GRAPHICS:

Location Plan
Site Plan VAB Area
Site Plan Launch Pad 39A

OTHER EQUIPMENT SUMMARY:

Sensors, controls, and some remote units will be installed in the HVAC subsystems, sewage subsystems, fire alarm subsystems, and 60 Hz electrical power subsystems in the facilities being modified and/or constructed and funded under the Shuttle CoF program. These are required for the initial operations of

these Shuttle Facilities, but are not a part of the project as outlined above. The total estimated cost of this other equipment is approximately $615,000.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

It is estimated that about $3 million will be required in future CoF programs to complete this project and provide monitoring and control of the 60Hz electrical power in the Industrial Area and integration of the total system. However, this FY 1977 third increment is fully operable and usable by itself and not dependent on any such future funding.

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CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE:	Construction of Addition for Aeroelastic Model Laboratory
INSTALLATION:	Langley Research Center
FY 1977 CoF ESTIMATE:	$730,000

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Technology

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	58,000	---	58,000
Other affiliated funding	---	13,423,000	13,423,000
Total	58,000	13,423,000	13,481,000

SUMMARY PURPOSE AND SCOPE:

This project will provide for an addition of an aeroelastic model laboratory to the Transonic Dynamics Tunnel (TDT), Building 648. The aeroelastic model laboratory will house a new cable model support system, a model shake test run-up area; and a data system and instrumentation service area.

The TDT is a unique facility designed specifically to meet aeroelastic testing requirements. The demand for the facility is such that a backlog of programs totalling approximately two years duration presently exists. This proposed addition will increase operational efficiency of the TDT by increasing the time the tunnel is available for testing. It will allow for extensive pre-test preparation of models outside

of the tunnel test section, a capability which is severely limited at present. It will also consolidate all pre-test model preparation activities into one area. Currently, the rotor test equipment is located in Building 1294 which is situated in the West Area about 4 miles (6.2 kilometers) away.

PROJECT JUSTIFICATION:

The Transonic Dynamics Tunnel is a unique facility in that it was designed specifically to meet aeroelastic testing requirements. Specifically, the tunnel uses Freon gas rather than air, as a test medium. Freon properties make it possible to build dynamically scaled aeroelastic models of current highly structurally efficient aircraft. The speed of sound in Freon is one-half that of air, which reduces the tunnel power requirements since the air Mach numbers can be achieved in Freon at one-half air speed. Other features are a mechanism to quickly change test conditions to reduce forces when flutter occurs, a computerized data acquisition system designed to handle aeroelastic data, a gust generator, and a screen to catch models that may break up during flutter tests before they destroy the tunnel blades. There is no known facility in existence in the "free world" that has been designed to meet these requirements.

It is anticipated that the proposed addition will improve the efficiency of tunnel operations in terms of occupancy time per tunnel test by about 15 to 20% for a typical operational year. At the present time, the tunnel has a total backlog of work for approximately two years with a definitive schedule established for the first year. Based on this 1976 schedule, eight to ten weeks test occupancy time can be saved out of a total tunnel operational year of 45 weeks, allowing seven weeks down time for maintenance. Models of most high speed U. S. developed aircraft are tested in this tunnel for flutter clearance and other aeroelastic conditions. During 1976, DOD and NASA aircraft programs will account for 50% of tunnel time, 36% for R&T programs, and 14% for maintenance. DOD support included testing such airplanes as the F-4, F-14, F-16, B-1, and C-141. The NASA programs include highly maneuverable aircraft, two supersonic speed configurations and four entries of shuttle models; three for flutter and one for parachute evaluation.

This project will also provide engineers and technicians with a consolidated space for setting up models, data evaluation, and providing "real time" test direction.

PROJECT DESCRIPTION:

The project will be a 4,965-square foot (461 square meter) third floor addition to the Transonic Dynamics Tunnel, Building 648. The exterior of the addition will be similar in appearance to the existing building and the structural design will be compatible with that of the existing structure. The new addition will be divided into an aeroelastic model preparation area which will include an active cable mount model support, duplicating the one in the tunnel, a protected rotor run-up area, and a data system and instrumentaiton service area. All necessary utilities will be provided to the new addition.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				545,000
Building addition	SF	4,965	68.50	340,000
Mechanical	LS	---	---	90,000
Electrical and substation	LS	---	---	115,000
Equipment				185,000
Cable mount system	LS	---	---	120,000
Instrumentation	LS	---	---	65,000
Fallout Shelter (not feasible)	---	---	---	---
Total				730,000

LIST OF GRAPHICS:

Location Plan
Single Line Drawing with Perspective

OTHER EQUIPMENT SUMMARY:

No other collateral or noncollateral is involved.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

At the present time, there is no requirement foreseen which would require future CoF funding for this project.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE:	Construction of Data Reduction Center Annex
INSTALLATION:	Langley Research Center
FY 1977 CoF ESTIMATE:	$2,970,000

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT HEADQUARTERS OFFICE: Office of Center Operations

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	228,000	---	228,000
Other affiliated funding	---	8,332,000	8,332,000
Total	228,000	8,332,000*	8,560,000

* NOTE: This value excludes $38,977,000 of noncollateral R&D computer equipment.

SUMMARY PURPOSE AND SCOPE:

This project will provide critically needed floor space for improving the computational capability of the Langley Research Center (LaRC). Requirements for such space have continued to grow in pace with increasing demands by the research programs for computational support. Realignment and consolidation actions to gain space for additional equipment have been extensively employed. By relocating personnel to other buildings, and by converting office space to maintenance and tape storage functions, space has been gained for the initial installation of the String Array (STAR) Computer.

The proposed construction is a 30,000 square foot (2,787 sq. m.) annex to the Data Reduction Center, Building 1268, to be located immediately southeast of that building. Approximately a 15,000 square foot (1,394 sq. m.) area with an elevated floor will be provided to house the environmentally controlled computer equipment. In addition, 5,000 square feet (465 sq. m.) of space are required for mechanical and electrical utilities, with the remaining space devoted to housing supporting operations and maintenance personnel.

PROJECT JUSTIFICATION:

Virtually all research activities at LaRC require heavy use of computation and data handling facilities. The increased complexity and cost of aerospace designs have led to the development of more comprehensive analysis programs, more elaborate models which are tested with resulting large volumes of data, and increased use of real time simulation to evaluate overall designs. As computer studies become more practical alternatives to wind tunnel and flight tests, the demand for computational support continues to grow. The curtailment of experimental testing to reduce the Center's energy requirements and limitations in the research personnel complement have catalyzed the application of computers to the solution of research problems.

The expanding use of computing is delineated in a LaRC assessment that identifies several research areas requiring increased computational support in succeeding years. Major hardware and software installations now underway and scheduled for the next two years should result in a substantial improvement in the computing capability available to support Center programs. The installation of the STAR computer will provide capacity for solving large analytical problems which have been impractical in the past. The availability of this computer to the LaRC staff and to researchers at other NASA Centers will constitute a major Agency research capability. Effective use of this computer will require a period of program development to capitalize on its capabilities and increased speed. Anticipating this evaluation period, the initial STAR system was acquired with minimal memory and peripheral devices. Subsequent expansion of memory, disk, and mass storage capacity, along with the development of the STAR communications subsystem, will be required to permit its effective use throughout the Agency. The accompanying installation of hardware to expand the real time simulation computing capacity will provide a means for detailed modeling of rotor systems and their controls for helicopter studies and for advanced control studies required by such projects as the Active Controls Technology Program. The recent introduction of interactive computing facilities is providing vast improvements in computer accessibility, but requires increased on-line file storage. These new capabilities will be fully exploited by providing increased mass storage and computer communications.

Although some existing equipment now in use will be removed, the aggregate increase in required equipment, utility, and personnel space cannot be accommodated within the available floor space. Intensive site planning activities have been underway for sometime to arrange for the installation of equipment

scheduled for delivery through 1977. Major relocations of both personnel and equipment within the present space, as well as to other buildings, will be required. These actions will provide only interim arrangements under circumstances which cannot be sustained without seriously compromising operations. This proposed new facility will provide space for the mass storage and computer communications equipment to be installed in the 1979-80 time frame. Because of the immediate need to use space that was originally planned for simulation equipment for flight control and handling qualities studies, advancement of that research capability will be seriously constrained.

PROJECT DESCRIPTION:

This project will provide for a 30,000-sq. ft. (2,787 sq. m.) annex to the Data Reduction Center, B-1268. The various areas within this facility will be designed to provide space for archival data storage and retrieval, 5,000 sq. ft. (465 sq. m.); on-line mass data storage equipment, 5,000 sq. ft. (465 sq. m.); network communications and control equipment, 5,000 sq. ft. (465 sq. m.); equipment maintenance, 1,250 sq. ft. (115 sq. m.); computer management personnel, 2,700 sq. ft. (251 sq. m.); tape storage, 1,800 sq. ft. (167 sq. m.); systems analysis, 1,250 sq. ft. (115 sq. m.); hall, toilets and stairwells, 3,000 sq. ft. (279 sq. m.); and mechanical and electrical equipment, 5,000 sq. ft. (465 sq. m.).

The construction of this new facility will consist of a metal frame structure, exterior walls of brick and metal panels, and built-up roofing. This project also includes heating, air conditioning, lighting, special electrical, and all necessary utilities. Equipment bays will be outfitted with elevated flooring and provisions for related electrical and air conditioning equipment. Cable ducts will be provided to allow interconnection of equipment in the annex to main frame computing equipment in the Data Reduction Center. Fire protection is provided throughout this facility with an Automatic Fire Detection and Wet Pipe Sprinkler Systems. Also included in the project are the utilities outside of the building with the electrical, sanitary and water connections to the existing systems. The exterior electrical system will include a new substation and all of the necessary electrical equipment required to make this system operational.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition.....	---	---	---	---
Construction.....				2,970,000
Site development.....	LS	---	---	17,000
Architectural/structural.....	SF	30,000	30.20	906,000
Mechanical (inside 5' line).....	SF	30,000	26.65	800,000
Electrical (inside 5' line).....	SF	30,000	10.70	321,000
Fire Protection Systems.....	SF	30,000	3.70	111,000
Special Electrical.....	LS	---	---	160,000
Utilities (outside 5' line).....	LS	---	---	655,000
Fallout Shelter (not feasible).....	---	---	---	---
Total.....				2,970,000

LIST OF RELATED GRAPHICS:

Location Plan
Single Line Drawing with perspective

OTHER EQUIPMENT SUMMARY:

The Data Reduction Center Annex will house approximately $10,000,000 of computer equipment of a noncollateral nature provided from R&D resources. There is no additional collateral or other equipment required by this project.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

At the present time, there is no foreseen requirement which would require future CoF funding for this project.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE: Construction of Refuse-Fired Steam Generating Facility

INSTALLATION: Langley Research Center

FY 1977 CoF ESTIMATE: $2,485,000 *

LOCATION OF PROJECT: Hampton, Virginia

*NOTE: This is the NASA portion of a jointly-funded facility.

COGNIZANT HEADQUARTERS OFFICE: Office of Center Operations

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding.....	37,000**	---	37,000
Other affiliated funding.....	---	---	---
Total.....	37,000	---	37,000

** NOTE: This is to be a jointly financed project in the manner indicated below with such joint financing to provide for both design and construction activities.

SUMMARY PURPOSE AND SCOPE:

This project provides for construction of a Refuse-Fired Steam Generating Facility at Langley Research Center (LaRC) which is jointly sponsored by LaRC, USAF/Langley Air Force Base (USAF/LAFB), and the City of Hampton, Virginia. The facility will have a capacity for burning about 225 tons (204,000 kilograms) of refuse daily and converting this energy into steam. Operation of the facility will alleviate the area's problems of both the Government and the community (solid waste disposal) as well as provide a significant reduction in fuel oil (energy) requirements for LaRC. The total cost of the project is estimated at $8,410,000 to be met on an agreed basis between the U.S. Government (NASA/LaRC and USAF/LAFB)

and the City of Hampton, Virginia. Under this agreement, NASA/LaRC will provide $2,485,000 additional to the $37,000 planning and design funds already made available, the USAF/LAFB $800,000, and the City of Hampton, Virginia, the remaining $5,088,000 to make up the total estimated cost.

Title to the facility will be vested in the LaRC and a long term agreement with the City of Hampton, Virginia, is planned for its operation and maintenance including the provision of steam needed by LaRC.

LaRC is participating in this project which responds to Executive Order 11752 which encourages the full cooperation of the Federal Government with local governments for the prevention, control and abatement of environmental pollution and also in response to the current energy situation. Additionally, it is anticipated this facility will help reduce the long term maintenance and operational costs at the Center.

PROJECT JUSTIFICATION:

LaRC and LAFB currently dispose of refuse by a landfill operation performed on property located on LAFB. The general elevation of the land is such that in processing the burial of the refuse, the water table is exposed and in contact with the refuse. This results in "leaching out" of contaminants from the refuse to the ground and tidal water. Suitable land for improved disposal operation is not reasonably available in the general area. The City of Hampton's landfill site experiences similar problems with respect to water pollution. In addition, the location of the City's landfill site is in direct line with the approach to the LAFB runway. Attraction of birds to the landfill site operations generates a "bird strike" problem with potential impact to aircraft using LAFB. The proposed Refuse-Fired Steam Generating Facility will eliminate the above problems.

In addition, the proposed facility offers a significant contribution to the energy conservation program. At present, LaRC obtains steam from its oil-fired boiler plant, using approximately 3,500,000 gallons (13,248,000 liters) of fuel oil per year. This plant now supplies steam for building heating and hot water requirements and for research facility loads such as steam ejector associated with the various wind tunnels. The proposed refuse-fired plant will result in an estimated "savings" of 2,900,000 gallons (10,976,000 liters) of fuel oil per year, which translates into about $800,000 per year at current fuel oil costs (27.6¢/gallon). The existing steam plant will continue to be utilized for peak loads generated by research operating demands and during severe winter conditions.

This refuse-fired plant will produce a nominal amount of nonorganic, nonpollution residue which will be disposed of at the City of Hampton's present landfill area. The existing Government's landfill operation will be terminated when the new facility becomes operational. The salvage of some scrap metals will further reduce the residue from the plant.

The proposed facility will be located at LaRC and title will be vested in the LaRC. The Center will enter into a long term agreement with the City of Hampton, Virginia, for the operation and maintenance of this facility and for the provision of steam to LaRC. It is planned that operating and amortization costs will be offset by steam charges to LaRC which will be based on current production costs for equivalent steam quantities. It is estimated that the LaRC investment of some $2.5 million will be amortized through "cost savings" in four to five years.

In summary, the new Refuse-Fired Steam Generating Facility will eliminate the very marginal landfill operations on Government property, provide substantial reduction of the City's landfill operations, meet the Environmental Protection Agency's pollution regulations, eliminate "bird strike" hazard impact to LAFB aircraft, and conserve natural energy resources (fuel oil).

PROJECT DESCRIPTION:

The project provides for construction of a boiler plant capable of burning as fuel about 225 tons (204,000 kilograms) per day of waste products to generate some 56,000 pounds per hour (25,400 kilograms/hour) of steam at about 350 psig (2,413,000 newton/meter^2). The plant will consist of one boiler and ancillary systems which will include forced and induced draft fans, feed water system, ignition and combustion controls, as well as stack emission treatment meeting environmental standards. Incorporated in the plant complex will be material handling and processing equipment, conveyors, and other related systems and services necessary to make a complete self-sustaining plant. The plant will be located in the West Area of the Center adjacent to State Highway 172 and west of the Impact Dynamics Research Facility, Building 1297. Included in the project are an entrance road to this proposed facility and security fencing for the area. Existing electrical power, water and sewer systems will be extended to provide these services to the facility. A steam distribution line to the proposed facility is included with this project.

The environmental impact of this facility has been assessed and it is expected to be comparable with similar type plants located in the area. During the design and operation of this facility, the abatement of air and water pollution will be taken into consideration. The proposed construction will have no impact on the environment at LaRC. The operation of the facility will exhaust emissions of air pollutants lower than the existing heating plant and are not expected to have any harmful effects on the environment. An amendment to the Institutional Environmental Impact Statement will be prepared to reflect the addition of this facility and its operation.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				6,440,000
Boiler train	EA	1	---	2,070,000
Piling and concrete (foundations, ramps, roads, and paving)	LS	---	---	570,000
Building and structural steel	LS	---	---	815,000
Mechanical and electrical equipment	LS	---	---	2,985,000
Equipment				1,970,000
Material handling and processing, conveyors, blowers, pumps, etc	LS	---	---	1,970,000
Fallout Shelter (not feasible)	---	---	---	---
Total for Design and Construction				8,410,000
Included in this project for NASA financing.				2,485,000

It is noted that this project is an exception to normal procedure, in that as a jointly financed project, it includes design and construction costs since these are to be shared by the three sponsors.

LIST OF RELATED GRAPHICS:

Location Plan
Single Line Drawing

OTHER EQUIPMENT SUMMARY:

None is required to support the presently planned concept of operation.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

There are no currently foreseen future funding requirements necessary to complete this project.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE: Modification of Refrigeration System, Electric Propulsion Laboratory

INSTALLATION: Lewis Research Center

FY 1977 CoF ESTIMATE: $680,000

LOCATION OF PROJECT: Cleveland, Cuyahoga County, Ohio

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Technology

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	52,000	---	52,000
Other affiliated funding	---	5,169,000	5,169,000
Total	52,000	5,169,000	5,221,000

SUMMARY PURPOSE AND SCOPE:

This project will provide the necessary modifications to the refrigeration system of the two existing space environmental vacuum tanks located in the Electric Propulsion Laboratory, Building 301. This facility is for the testing of spacecraft, solar arrays, and ion thruster propulsion systems and components in simulated space conditions. Since the facility became operational in 1961, liquid nitrogen has been used as the refrigerant to meet the space temperature requirements in the vacuum tanks. Recent and projected increases in the cost of liquid nitrogen necessitate the modification of the refrigeration system to one less expensive to operate.

This project provides a new "closed-loop" mechanical refrigeration system capable of maintaining the cold wall temperature between -75°F (-59°C) and -100°F (-73°C) which is considered adequate to meet present and foreseeable test requirements.

PROJECT JUSTIFICATION:

Two of the Electric Propulsion Laboratory vacuum tanks are used to test electric ion thruster propulsion systems and components, spacecraft and solar arrays such as the Communication Technology Satellite. The outer space environment temperature requirement is currently being simulated by a liquid nitrogen cooling system at -300°F (-184°C) cold wall temperatures within the vacuum tanks. The present and foreseeable testing, however, can be conducted at a cold wall temperature between -75°F (-59°C) to -100°F (-73°C).

At the cold wall temperature level requirements of -75°F (-59°C) to -100°F (-73°C) the proposed "closed-loop" (freon) mechanical refrigeration system addition will provide this cold wall refrigeration at a substantial savings in energy and operational costs as compared to the existing "open-loop" liquid nitrogen refrigeration system.

At present cost levels, an annual operational cost "savings" could be $540,000. This would probably increase to over $750,000 in 1980 reflecting the increasing cost of liquid nitrogen which can be reasonably anticipated. Within one year after installation of the proposed new refrigeration system, the capital investment would be returned and thereafter reflect an annual "savings" of possibly even larger amounts. The existing liquid nitrogen system will remain installed and intact for any future use which may evolve requiring the greater capabilities.

PROJECT DESCRIPTION:

The project provides a 40-ton capacity "closed-loop" (freon) mechanical refrigeration system, stainless steel cold walls (baffles) with radiation shielding in two vacuum tanks, refrigeration piping with insulation, utility services, electrical power and controls, and a building addition of about 690 gross square feet (64 square meters) to house the refrigeration equipment. Remote control of the refrigeration system will be from an existing control room.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				40,000
Building addition	SF	690	58.00	40,000
Equipment				640,000
Mechanical refrigeration equipment	Ton	40	8,000.00	320,000
Stainless steel (cold wall baffles)	Lbs	7,000	7.80	55,000
Equipment installation	LS	---	---	105,000
Provision of electric power and controls	LS	---	---	160,000
Fallout Shelter (not feasible)	---	---	---	---
Total				680,000

LIST OF RELATED GRAHPICS:

Location Plan
Single Line Drawing

OTHER EQUIPMENT SUMMARY:

No other collateral or noncollateral equipment is involved.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

There are no currently foreseen future funding requirements to complete this project within the defined scope.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE:	Rehabilitation of Combustion Air Drying System, Engine Research Building
INSTALLATION:	Lewis Research Center
	FY 1977 CoF ESTIMATE: $1,490,000

LOCATION OF PROJECT: Cleveland, Cuyahoga County, Ohio

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Technology

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	25,000	---	25,000
Other affiliated funding	---	11,141,000	11,141,000
Total	25,000	11,141,000	11,166,000

SUMMARY PURPOSE AND SCOPE:

This project will provide for the replacement of the combustion air drying system in the Engine Research Building (ERB). Within this building there are 55 individual test cells involved in a wide variety of research projects. Although the individual requirements of these cells vary greatly, they collectively depend on the ERB central air handling system for their operation. This central air system must have the capability to simulate a broad spectrum of test environments including extremely low moisture content for basic component research in support of air breathing, rocket and ion engine programs.

The existing air drying system which utilizes ammonia refrigeration equipment has been in service for over 30 years. Because of its present condition, it can no longer meet the users' demand for dry air. Further, ammonia leaks have been detected and repairs made in the vicinity of the equipment and within the individual test cells inside of the building.

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The new combustion air drying system to be provided by this project will consist of chilled water to air heat exchangers and desiccant dryers with sufficient capacity to meet all present and known future test requirements at the Lewis Research Center (LeRC).

PROJECT JUSTIFICATION:

The existing ammonia combustion air drying equipment has been identified by the LeRC Safety Office as a high "risk" item which should be replaced. Reliability is deteriorating and maintenance requirements are increasing. Condition of the existing system is such that its performance has to be degraded from its original design capacity of 70 pounds per second (32 kilograms per second) to 55 pounds per second (25 kilograms per second). Further, the existing system can only provide dry air at -20°F (-29°C) dew point temperature. This reduced capability is not sufficient for meeting many present test requirements which include basic component research in support of air breathing, rocket and ion engine programs. Many of these investigations require that the moisture content of the incoming air be controlled within specified limits. In some cases meaningful test data can only be obtained if the vapor level is reduced to an absolute minimum. Within practical limits, this test requirement can be met by providing dry air at a dew point temperature of -100°F (-73°C). The proposed new combustion air drying system will provide 70 pounds per second (32 kilograms per second) of dry combustion air at a dew point temperature of -100°F (-73°C). Reliability will be increased and maintenance requirement will decrease. Further, the new system will eliminate the current safety risks associated with the existing ammonia system.

PROJECT DESCRIPTION:

This project consists of removing the old dryer equipment, consisting of ammonia compressors, condensers, heat exchanger, interconnecting piping, and associated concrete foundations. New dryer equipment will be provided consisting of three heat exchangers, two 250-ton capacity package-type water chillers, three desiccant dryer tanks with a regeneration system, interconnecting piping, and associated concrete foundations. Necessary valves, electrical work, controls and safety devices are also included with this project.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				60,000
Site preparation	LS	---	---	35,000
Building modifications	LS	---	---	25,000
Equipment				1,430,000
Precooler	EA	1	90,000	90,000
Refrigeration air dryer	EA	2	240,000	480,000
Desiccant air dryer	EA	3	207,000	621,000
Valves, piping and equipment installation.	LS	---	---	179,000
Provision of electric power and controls..	LS	---	---	60,000
Fallout Shelter (not feasible)	---	---	---	---
Total				1,490,000

LIST OF RELATED GRAPHICS:

Location Plan
Single Line Drawing

OTHER EQUIPMENT SUMMARY:

No other collateral or noncollateral equipment is involved.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

There are no currently foreseen future funding requirements to complete this project within the defined scope.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE: Large Aeronautical Facilities	
	FY 1977 CoF ESTIMATE: $25,000,000

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Technology

SUMMARY PURPOSE AND SCOPE:

The purpose of this project is to provide for the construction and modification of large aeronautical research and development testing facilities. The planning related to these large aeronautical facilities has been supported jointly by NASA and Department of Defense. These facilities are included in a program/plan to provide for major and unique aeronautical test facilities required over the next two decades. The facilities will have the testing capability necessary for the development of technology that will continue to provide this country with superior and more fuel-efficient military and civil aircraft.

The NASA Large Aeronautical Facilities included in this program/plan are:

1. Construction of National Transonic Facility (NTF). This is a high Reynolds number transonic tunnel to be located at Langley Research Center (LaRC) which will combine into a single facility the capabilities needed to satisfy the research needs of NASA and the development needs of Department of Defense (DOD).

2. Modification of 40 x 80-Foot Subsonic Wind Tunnel. This is a full-scale wind tunnel located at Ames Research Center (ARC) dedicated primarily to investigating flight characteristics of rotorcraft and V/STOL aircraft and supplies the research needs of NASA and development needs of the DOD.

The NASA Fiscal Year 1977 request provides for the initiation of long-lead procurement items for the construction of the National Transonic Facility at LaRC. Future years' Construction of Facilities (CoF) resources will, of course, be needed to complete this facility. This year's estimates under Facility Planning and Design also provide for the completion of the final design for the NTF and for the continuation of the design effort on the 40 x 80-Foot wind tunnel modifications. Consideration will be given to the requirements for the modification of the 40 x 80-Foot Subsonic Wind Tunnel in future years' programs.

PROJECT TITLE: Construction of National Transonic Facility

INSTALLATION: Langley Research Center

FY 1977 CoF ESTIMATE: $25,000,000

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Technology

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	2,160,000	---	2,160,000
Other affiliated funding	---	4,942,000	4,942,000
Total	2,160,000	4,942,000	7,102,000

NOTE: Additional Planning and Design resources will be provided on an interim basis as outlined in the Facility Planning and Design Budget Estimates.

SUMMARY PURPOSE AND SCOPE:

This project provides for the construction of a high Reynolds number transonic tunnel which will satisfy the research needs of NASA and the development needs of DOD. This facility will provide a capability to test a broad spectrum of aeronautical vehicles including civilian, commercial, military, and space vehicles at up to full-scale Reynolds number. It will incorporate a cryogenic approach for achieving high Reynolds number without excessive model loads and will use the evaporation

of liquid nitrogen to obtain a low temperature test medium in an otherwise conventional fan-driven wind tunnel circuit. With temperature as a test variable, the facility will allow clear separation of aeroelastic, Mach number, and Reynolds number effects on the aerodynamic performance of configurations. This ability to separate these effects has heretofore been unattainable in ground facilities, thus the new tunnel provides an entirely new realm of research capability.

During FY 1975, both NASA and the USAF had planned dedicated transonic facilities to satisfy their respective needs for high Reynolds number research and development testing of future aircraft. A High Reynolds Number Tunnel (HIRT) employing a "Ludwieg tube" concept to be located at the Arnold Engineering Development Center, Tullahoma, Tennessee; and another, called the Transonic Research Tunnel (TRT), a continuous-flow, cryogenically-cooled facility to be located at the NASA Langley Research Center (LaRC) were considered. Subsequently, rising construction costs for both facilities, coupled with the successful demonstration of the "cryogenic concept" at LaRC, led the Aeronautics and Astronautics Coordinating Board to reconsider the need for two separate and distinct facilities. As a result, it was determined that a single facility to be provided at a lower cost and using the "cryogenic concept" could best serve the immediate needs of both NASA and DOD. It has also been agreed that this single facility would be located at LaRC.

PROJECT JUSTIFICATION:

There is an urgent need, established over recent years, for several new ground-based facilities for aerodynamic testing at transonic speeds and at flight Reynolds numbers. In spite of spectacular advances in aerodynamics during the last 20 years, a number of leading aircraft developments have encountered difficulty because of misleading or inadequate wind tunnel testing in the transonic regime. This need is supported by U.S. Department of Defense, the U.S. aerospace community, and by the North Atlantic Treaty Organization Advisory Group for Aerospace Research and Development (AGARD). This requirement stems from the recognition that experimental data obtained from existing low Reynolds number transonic wind tunnels often leads to erroneous conclusions with regard to flight vehicle performance predictions. This is especially true for conditions where local velocities over the vehicle surface exceed the speed of sound and where shock-boundary layer interaction effects occur. The transonic flight environment is common to a broad spectrum of flight vehicles, such as civilian, commercial, military, and space. This environment also produces Reynolds number sensitive aerodynamic problems which are generally not amenable to analytical study and, thus, require accurate experimental data at or near flight Reynolds number for an adequate solution.

Therefore, a wind tunnel which will permit accurate experimental measurement at transonic speeds approaching flight Reynolds number is necessary for the continuing development of new technology. This will allow increases in efficiency, performance, size and range of civil and military aircraft

which is the basis for maintaining national leadership in aircraft design and the superiority of U.S. military flight vehicles. Thus, the urgency for the new testing capability suggests that this facility should be available at the earliest possible time.

The capability to simulate full-scale Reynolds numbers on a model in a wind tunnel at which Mach numbers near 1.2 requires a workable test section size of 8.2 x 8.2 feet (2.5 m x 2.5 m) with a maximum operating pressure on the order of 130 psia (896,000 newtons per square meter). It also requires run times sufficiently long to permit accurate data measurements for the complete spectrum of aerodynamic research. The quality of the test air flow should be of the highest practical level.

There is no known wind tunnel in existence in the United States or Europe that will satisfy the above requirements.

PROJECT DESCRIPTION:

The project will provide for the construction of a fan-driven closed circuit wind tunnel 200 feet (61 m) long by 48 feet (14.6 m) wide, varying in diameter from 40 feet (12.2 m) to 11 feet (3.4 m), having an operating pressure range from 14.7 psia (101,400 newtons per square meter) to a maximum of 130 psia (896,000 newtons per square meter) and an operating temperature range from 155°F to -300°F (341.5°K to 88.7°K). Cryogenic gas temperature will be obtained by evaporating liquid nitrogen into the tunnel circuit. Thus, cold nitrogen gas will be used as a test medium. The tunnel pressure shell will be fabricated from nickel steel and insulated internally to efficiently contain the cold gas. A fixed-pitch single-stage fan will drive the tunnel air flow through a 8.2 x 8.2-foot (2.5 x 2.5 m) slotted test section to produce Mach numbers over the range between 0.2 and 1.2.

The cryogenic approach described above has been identified as the most effective energy reduction technique of achieving high Reynolds numbers without excessive model loads.

A three dimensional model support and angle-of-attack system having an angle range of 24 degrees will be incorporated in the test region. A roll mechanism will be an integral part of the support system and will be capable of rolling the model through 180 degrees. Windows in the walls of the slotted test section will be provided for remote television view of the model under test.

The tunnel will be constructed on the site of the currently existing 4 x 4-foot (1.2 x 1.2 m) supersonic tunnel and will use its electric motor drive system. These motors are rated at 47,000 HP (35,062 KW) for continuous duty. They are capable of 70,000 HP (52,220 KW) for run times up to 10 minutes. A two-speed gear system will be provided to match the compressor with the motors at both ambient and cryogenic temperatures. A liquid rheostat will also be provided to achieve a constant torque from the motor over a wide range of RPM, thus improving the power characteristics of the

motors for the new application. An additional 60,000 HP synchronous drive motor (44,760 KW) (10 minute rating) will be required to provide the higher Reynolds numbers. The proposed facility will also utilize the existing cooling tower, pumps, auxiliary equipment and buildings. A new two-story shop addition of approximately 33,500 square feet (3,112 m^2) to accept the larger transonic test section will be provided. This shop will include space for a control and data acquisition room and for improved model preparation area. Adequate controls, process monitors, and data acquisition systems are included in this project.

A liquid nitrogen storage and supply system will be provided on the site to allow nitrogen flows to the tunnel at rates up to about 1,100 lbs. (499 Kg per second). This flow is required to remove the heat generated by the compressor during constant cryogenic temperature operation. Additionally, a vent and pressure control is provided to maintain constant pressure during data gathering. The vent will be provided with a muffler and exhaust stack to meet pollution control standards.

Due to the size and nature of this facility, it is considered appropriate to plan its financing on a progressive basis over three fiscal years. An analysis of schedules and capabilities indicates that such funding will not materially impact the operational schedule for this large facility which is presently envisioned as being mid-1981 which is based on this FY 1977 increment of funding. Preliminary engineering estimates indicate that the total ultimate cost of this facility will most probably be $65 million depending on the time frame of construction and the ultimate degree of cost escalation encountered. Considerable preliminary engineering and special studies have already been completed. The final design for this facility was initiated in October 1975.

The FY 1977 request will provide for the demolition and removal of the existing tunnel shell and that portion of the building not to be reused. Also included in this project is the construction of foundations for the new tunnel and building utilizing the existing foundations where possible. Approximately 600 new piles varying in length from 27 feet (8.2 m) to 40 feet (12.2 m) will be required. The new piles will consist of a combination of treated wood, concrete and steel as required for the specific location and loading.

This fiscal year also will permit the procurement of all the materials for the tunnel pressure shells. The funds for the first phase of the fabrication and erection of the tunnel pressure shell are also included in this year's estimates. It will also provide for the fabrication of the tunnel structure components (i.e.; test section, model support section, screens and turning vanes); the fan components (fan blades and stator vanes and hub); the tunnel cooling coil; and the model support system. The first phase of the tunnel drive system which includes the procurement of the additional drive motor is also included. Two subsequent phases of the drive system will include the procurement of the remaining items such as gearbox units, drive shafts and bearings, and the installation of the drive system.

Preliminary studies concerning possible environmental impacts caused by this facility have been completed. These studies have indicated that noise, venting of large volumes of nitrogen gas, and possible formation of ground fog caused by cold nitrogen gas venting are potential problem areas. However, these areas can be adequately controlled through the design of this facility and LaRC anticipates no adverse effects on the envirornment. It is therefore planned to amend the overall Langley Research Center Environmental Impact Statement to cover the National Transonic Facility.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				18,900,000
Demolition and foundations	LS	---	---	1,400,000
Tunnel pressure shell: materials, fabrication, and erection (Phase I)	LS	---	---	8,700,000
Tunnel structure components fabrication	LS	---	---	8,800,000
Equipment				6,100,000
Tunnel drive system (Phase I)	LS	---	---	2,600,000
Fan components fabrication	LS	---	---	2,300,000
Cooling coil fabrication	LS	---	---	400,000
Model support system fabrication	LS	---	---	800,000
Fallout Shelter (not feasible)	---	---	---	---
Total				25,000,000

This estimate provides only for the FY 1977 increment of the total facility, now estimated to cost about $65 million which would be funded in this and perhaps two additional fiscal years.

LIST OF RELATED GRAPHICS:

Location Plan
Perspective View
Second Floor Plan and Tunnel Layout
Tunnel Aerodynamic Lines
Test Section Elevation

OTHER EQUIPMENT SUMMARY:

Existing collateral equipment consisting mainly of the electric drive motors and a portion of the building for the 4-Foot Supersonic Wind Tunnel will be used in this facility. The total "book value" of the 4-Foot Supersonic Wind Tunnel is about $4,942,000. No other noncollateral equipment is involved.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

To complete the construction of the National Transonic Facility, about $40 million additional will be required in future years.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE:	Space Shuttle Facilities
INSTALLATION:	Various Locations
	FY 1977 CoF ESTIMATE: $39,825,000

LOCATION OF PROJECT: Locations are identified in the following documentation

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project.

	Planning and Design	Construction	Total
Specific CoF funding.....	10,265,000	99,317,000	109,582,000
Other affiliated funding.....	---	672,919,000	672,919,000
Total.....	10,265,000	772,236,000	782,501,000

The above is summary data only for the projects included in this submittal. For clarification purposes it is noted that prior to FY 1977 a total of $24.3 million has been made available for shuttle for planning and design in addition to a total of $230 million for shuttle facilities construction.

SUMMARY PURPOSE AND SCOPE:

The purpose of these projects is to modify and add to existing government-owned facilities and to construct a limited number of 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 as set forth in the project documentation and/or the assumptions on which total shuttle facility needs have been based and projected.

In FY 1977, the shuttle facilities proposed are again primarily for launch and landing requirements at John F. Kennedy Space Center (KSC). The work includes continuing modifications to Launch Complex 39 and completing construction of the Orbiter Processing Facility (OPF), which were both initiated with FY 1975 resources. As a continuation of the FY 1976 project it is also planned to modify existing facilities to provide capacity for the recovery, washing, refurbishment, and subassembly of solid rocket boosters (SRB's) and SRB parachutes. The construction of a shuttle/carrier aircraft mating facility is also included.

Fiscal Year 1977 requirements at other locations include continuing modifications for crew training and external tank manufacturing and final assembly. Also included are minor rehabilitation and modification projects which are required to support the Space Shuttle Program and are therefore considered unique space shuttle projects.

PROJECT JUSTIFICATION:

Fiscal Year 1976 and prior years' CoF projects for the Space Shuttle Program authorized modification and construction of facilities for technological development, space shuttle main engine tests, manufacturing, ground tests, and launch and landing. Construction of the technological facilities, engine test facilities, and orbiter manufacturing and assembly facilities is complete and the facilities are operational. Construction of orbiter landing facilities is underway and modification of launch facilities has started. The remaining facilities authorized in prior years are in the final design phase.

The FY 1977 request is intended primarily to continue modifications to provide launch capability for the shuttle vehicle at KSC. These facilities are needed for initial operations at the launch and landing site. Three projects begun with prior year resources--modifications to Launch Complex 39, construction of the Orbiter Processing Facility (OPF), and modifications for SRB processing facilities--are continued. With the exception of Mobile Launch Platform II (MLP II), construction of the facilities must be completed six to twelve months before the first manned orbital flight to support extensive activation, launch processing system installation and prelaunch test and checkout. The request for MLP II begins the transition to provide launch capability to support higher flight rates at KSC. This facility is required at the time the second orbiter is delivered to KSC to provide support for integrating that orbiter with the ground facilities and equipment, as well as

support for the flight mission profile planned for 1981 and beyond.

The remaining projects in the FY 1977 request are intended primarily to support vital ground and flight test activities. They include continuing two prior years' projects which provided facilities for proper crew training and external tank manufacturing. A project for rehabilitation and modification of existing facilities uniquely required to support the shuttle program is also included.

Current space shuttle planning is based on achieving a first manned orbital flight in the second quarter of CY 1979 and attaining a flight capability of approximately 15 missions in CY 1981. This FY 1977 request is necessary to meet specific targets or intermediate milestones directly related to the major milestones. The individual project descriptions specify those respective milestones to which the facility is related.

PROJECT COST ESTIMATE:

Launch and Landing Facilities	35,355,000
Construction of Orbiter Processing Facility, Kennedy Space Center, Florida	3,750,000
Modifications to Launch Complex 39, Kennedy Space Center, Florida	19,855,000
Modifications for Solid Rocket Booster Processing Facilities, Kennedy Space Center, Florida	9,700,000
Construction of Shuttle/Carrier Aircraft Mating Facilities, Kennedy Space Center, Florida	2,050,000
Ground Test Facilities	2,540,000
Modifications for Crew Training Facilities, Johnson Space Center, Texas	780,000
Rehabilitation and Modification of Shuttle Facilities, Various Locations	1,760,000
Manufacturing and Assembly Facilities	1,930,000
Modification of Manufacturing and Final Assembly Facilities for External Tanks, Michoud Assembly Facility, Louisiana	1,930,000
TOTAL	39,825,000

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE:	Construction of Orbiter Processing Facility
INSTALLATION:	John F. Kennedy Space Center
	FY 1977 CoF ESTIMATE: $3,750,000

LOCATION OF PROJECT: Merritt Island, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project. This funding data does not include $3.9 million which is being redirected to this project by a Section 3 action to provide workstands which were previously planned for implementation from R&D, but now have been determined to be proper facilities charges.

	Planning and Design	Construction	Total
Specific CoF funding	1,034,000	21,540,000	22,574,000
Other affiliated funding	---	---	---
Total	1,034,000	21,540,000	22,574,000

SUMMARY PURPOSE AND SCOPE:

This project continues work begun with FY 1975 and FY 1976 funds for the Orbiter Processing Facility (OPF) at the Kennedy Space Center. The FY 1975 project provided for one high bay and a low bay for safing, maintenance, and checkout of the space shuttle orbiter. The FY 1976 increment provided for the construction of the second high bay structure. This year's project provides for outfitting the second high bay with the necessary gaseous, propellant, and special systems; adding 10,000 square feet (929 m^2) to the low bay for staging and logistic support activities; and erecting a security fence around the facility. This will complete the facility requirement for processing the orbiter at the Kennedy Space Center.

PROJECT JUSTIFICATION:

Upon returning from a space mission, the orbiter must undergo safing, maintenance, and checkout before it can be readied for reuse. The major operations include draining and purging all fuel systems,removing ordnance and all other hazardous elements, removing payloads brought back from space, inspecting the payload bay and crew cabin, repairing and replacing damaged components, and refurbishing 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 OPF for reinstallation in the orbiter. After these operations are completed, the mission payloads are inserted into the payload bay and the orbiter receives integrated system checkout before it is moved to the vehicle assembly building for integration and checkout with the external tank and boosters. To carry out these operations, which take approximately two-thirds of the total orbiter processing time between missions, the OPF is required.

The FY 1975 program provided the initial funds for the necessary facilities. That increment included constructing and equipping the first high bay for orbiter operations and the low bay for the support functions. The FY 1976 increment provided the basic structure only for the second high bay. This FY 1977 project provides for completing the OPF at the launch site. The work includes outfitting the second high bay with the essential high-pressure gas, liquid propellant, hydraulics, instrumentation, control, and other special systems necessary to carry out the vital orbiter processing functions. The project also includes an addition to the low bay to provide a staging facility for equipment and working personnel, and a chain link fence for safety and security of the operations.

It is necessary that the second high bay be outfitted and completely operational during the early phase of shuttle development. While both bays are designed to carry out all the delineated orbiter processing functions, it has been recognized that certain operations like safing are of a hazardous nature; others, such as thermal protection system refurbishment, are somewhat "dirty" and are incompatible with the clean environment required for the removal and insertion of payloads into the orbiter. For these reasons, it was deemed vital to have both bays available during the shuttle development phase when personnel are learning and developing operational procedures to perform the cited complex tasks safely and efficiently.

In this way, it is possible to separate incompatible activities if necessary during the early phases. In addition, completing the facility in the proposed time frame will greatly minimize the costly interference between the construction and the operational activities and result in the most optimum and economical means of completing the total facility construction in time to meet the needs. On that basis, FY 1975 and FY 1976 provided the required funds to implement the facility construction in the timely and efficient manner described. FY 1977 resources are necessary to complete the facility as planned.

The low bay portion of the OPF is required to provide the necessary staging and logistic support facilities for the entire operation. Since the initial planning, the functions to be performed and kinds and size of equipment needed to support the work have been better defined. The analysis revealed that additional low bay space is required to house ground support equipment and materials as well as tools, lockers, and administrative space for the large work force involved in orbiter operations. This project provides the necessary space for these important functions. Because of the hazardous operations involved in orbiter processing and because certain payloads will have security requirements, the OPF will be a restricted area. A chain link fence around the site is therefore necessary.

To meet the current schedule for the first manned orbital flight, the first orbiter must be delivered to Kennedy Space Center in the third quarter of CY 1978 for the necessary prelaunch activities. The first high bay, authorized with prior year funds, will be operationally ready by that time. The second high bay must be completed by the end of CY 1979 to support shuttle developmental flights as well as to receive the second orbiter, scheduled to arrive in the latter part of CY 1980. To achieve these objectives, FY 1976 provided the basic structure and this FY 1977 increment will complete all the required construction.

PROJECT DESCRIPTION:

This project continues construction work provided for with FY 1975 and FY 1976 funds. It provides for outfitting the second 29,200-square foot (2,712.7m^2) high bay provided for with FY 1976 monies. The outfitting includes installing the necessary special and launch-related systems -- including hypergolic; hydraulic; instrumentation/communication; environmental control; electrical; gaseous hydrogen, nitrogen, helium, and oxygen; liquid hydrogen and oxygen; compressed air; coolant; and utility control. The hypergolic system allows for disposal of hazardous fuels when the orbiter is safed. The electrical system will provide service to all portions of the workstands. Compressed air is used to operate tools. The environmental control system provides specially conditioned "clean" air to the orbiter during payload operations. The coolant system provides cooling for the orbiter during tests. Over 12,000 feet (3,657.6 m) of piping as well as the associated valves and joints, 52,000 feet (15,849.6 m) of wiring and cable, and approximately 1,000 feet (304.8 m) of duct work will be installed to accommodate these systems.

The project also provides for the construction of a two-story, 10,000-square foot (929m^2) addition to the north end of the low bay. It will be constructed of structural steel framing with masonry exterior walls and the necessary electrical and mechanical systems. In addition, 2,000 feet (609.6 m) of chain link fence with its attendant gates and posts will be installed around the entire facility site.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				3,750,000
Site preparation, fencing, and utilities	LS	---	---	180,000
Special and launch-related systems				3,100,000
Gaseous systems	LS	---	---	(480,000)
Liquid hydrogen and oxygen	LS	---	---	(500,000)
Hypergolic systems	LS	---	---	(570,000)
Electrical, instrumentation, and communication	LS	---	---	(950,000)
Environmental control	LS	---	---	(400,000)
Utility control, hydraulic and coolant systems	LS	---	---	(200,000)
Low bay addition	SF	10,000	47.00	470,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				3,750,000

LIST OF RELATED GRAPHICS:

Location Plan
Perspective of Orbiter Processing Facility
Floor Plan of Orbiter Processing Facility

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OTHER EQUIPMENT SUMMARY:

As currently defined, about $18 million to $20 million will be needed for noncollateral equipment. This equipment relates to the entire OPF, and not just this project, and consists primarily of test and checkout, servicing, handling, and auxiliary equipment required to support these orbiter processing operations.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

For presently planned usage, there are no currently foreseen future CoF funding requirements to complete this project.

CF 8-9-7L

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE: Modifications to Launch Complex 39

INSTALLATION: John F. Kennedy Space Center

FY 1977 CoF ESTIMATE: $19,855,000

LOCATION OF PROJECT: Merritt Island, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	4,718,000	48,465,000	53,183,000
Other affiliated funding	---	501,538,000	501,538,000
Total	4,718,000	550,003,000	554,721,000

SUMMARY PURPOSE AND SCOPE:

This project continues modifications to Launch Complex 39 begun with FY 1975 and FY 1976 resources to prepare the complex for shuttle launches. These FY 1975 and FY 1976 projects provided for modifications to two high bays in the Vehicle Assembly Building, the Launch Control Center, one mobile launcher, and one launch pad. This project primarily provides for modifying a second mobile launcher. Modifications include removing the launch umbilical tower to decrease weight; providing exhaust holes for orbiter main engines and solid rocket boosters; and altering the mobile launch platform's structural, electrical, and mechanical systems to accommodate the shuttle vehicle configuration. The project also provides for modifications to Pad A to reduce high acoustic levels generated from firing the space shuttle main engines and solid rocket boosters so that orbiter payloads will not be damaged during launch.

PROJECT JUSTIFICATION:

The Space Shuttle Program has consistently made maximum use of reconfigured equipment and facilities from the Apollo Program. This policy has helped to ensure the most economical shuttle program possible. Consistent with this policy and for effective operations, the shuttle will be mated, integrated and checked out on an existing mobile launcher to be modified for shuttle use. The shuttle will then be moved to the launch pad, using the mobile launcher as the launch platform. Previous appropriations provided for modifications to one mobile launcher; program requirements call for a second mobile launcher at this time. It can be provided by reconfiguring another existing mobile launcher used during the Apollo Program.

The second mobile launcher is necessary to support the checkout and operations of the second orbiter, currently scheduled to arrive at Kennedy Space Center in the third quarter of CY 1980. At that time, the orbiter must undergo extensive checkout and integration with the second mobile launcher, the ground support equipment, and the launch processing system to prepare it for launch operations. Once that phase is accomplished, both the facility and the orbiter will be used to support the scheduled flights in CY 1981 and beyond.

During the operational phase of the shuttle program, current planning indicates that three mobile launch platforms will be required to achieve the planned launch rate of 40 missions per year at Kennedy Space Center. It is currently estimated that one mobile launch platform can, after some experience, support approximately 15 to 16 launches per year. However, in the early phase of shuttle operations, the capability of a single launcher is significantly less. The build-up towards the higher capability occurs gradually and could extend over a 12 to 18-month period before the ultimate capability is achieved. This is primarily because of the time required for shakedown, checkout, and integration with the ground support equipment and shuttle hardware; the long period needed to develop and perfect countdown and launch procedures; and the learning period necessary to train the launch operation ground crews. In addition, it is anticipated that each mobile launcher will require refurbishment after each launch because of the direct impact of flame from the orbiter engines and the solid rocket boosters. As the Apollo Program revealed, the required refurbishment and the time to implement it would decrease after some period of learning. For these reasons, it is necessary to provide a second mobile launcher in this time frame.

A second portion of this project is needed to modify Pad A. During recent simulated model shuttle tests at Marshall Space Flight Center (MSFC), it was determined that excessive noise levels are created during main engine and solid rocket booster firing. These high acoustic levels are greater than those that payloads in the orbiter bay can tolerate. If the high levels are not alleviated, it is likely that payloads will be damaged and therefore unable to perform during the mission. Such a condition is of course unacceptable.

It would be possible to solve this acoustic problem by strengthening the orbiter structure or "beefing up" each payload to withstand the noise levels anticipated at launch. Such an alternative would result in increasing the weight of the orbiter and/or payloads, correspondingly degrading the overall shuttle system capacity. A ground-based solution to the noise problem, on the other hand, is the most cost-effective answer, particularly in view of the fact that the high acoustic levels are encountered at launch.

Modifications to the mobile launcher will require 2-1/2 years for completion; support systems, equipment installation, checkout, and activation will require another year. The second mobile launcher must be ready by the fourth quarter of CY 1980, when the second orbiter arrives at KSC. The modifications to Pad A must be completed before the first manned orbital flight, now scheduled for the second quarter of CY 1979. It is therefore necessary that this project be funded with FY 1977 funds.

PROJECT DESCRIPTION:

This project provides for modifications to an existing mobile launcher and to Pad A at Launch Complex 39. Modifications to the mobile launcher include removing the umbilical tower; relocating vehicle support and holddown points; reconfiguring engine exhaust openings; and modifying and installing electrical, mechanical, communications, and special systems. Materials and equipment that have been removed from the mobile launcher will be preserved for reuse.

The mobile launch platform, which was originally designed to accommodate Apollo hardware, is a two-story steel structure 25 feet high by 160 feet long by 136 feet wide (7.6 m by 48.8 m by 41.5 m). An umbilical tower extends 380 feet (115.8 m) above the deck of the launch platform and weighs approximately 10.5 million pounds (4.76 million kg). Electricity to meet power needs; gaseous nitrogen and helium to purge systems during hazardous operations; a deluge system to cool the steel deck during launchings; heating, ventilating, and air conditioning (HVAC); and a fire extinguishing system are provided for the platform. Much of the piping and cabling is contained inside the platform. Propellant lines for liquid oxygen and liquid hydrogen run outside the platform to the spacecraft. To adapt this large and complex facility to shuttle requirements, major modifications will be required.

The weight of the shuttle vehicle as it moves to the launch pad exceeds the weight of the unfueled Apollo/Saturn V vehicle by approximately 1.9 million pounds (861,840 kg). The mobile launcher must therefore be lightened to avoid overloading the crawler transporter. Removing approximately 2.6 million pounds (1,179,360 kg) of steel comprising the tower, two elevators, and equipment inside the mobile launcher not required for shuttle operations will reduce the weight sufficiently. Vehicle services will be provided from a fixed tower at the launch pad rather than from the mobile launcher. This fixed tower will be later constructed from salvaged sections of the removed umbilical tower.

The shuttle will require three exhaust openings in the mobile launcher--one approximately 32 feet by 35 feet (9.8 m by 10.7 m) for the orbiter main engine exhaust and two approximately 20 feet by 42 feet (6.1 m by 12.8 m) for the solid rocket boosters--instead of the one opening provided for the Apollo configuration. Girders, framing, deck plates, heat shields, and holddown arms will have to be removed. Piping for the HVAC system; ducts for the environmental control system; and lines for the pneumatic, propellant, water, and coolant systems will have to be rerouted to accommodate the new exhaust openings. Instrumentation, communication lines, controls, 60-Hertz power, lighting, and the lightning protection system must all be modified. A new fire alarm system and a hazardous gas detection system must be provided.

New support and holddown points for the solid rocket booster and new support points for the removable orbiter erection supports will be provided. Crawler transporter/mobile launcher support points will be relocated to balance the load. The reconfiguration will require modifications to the internal structure of the launcher as well as rerouting mechanical and electrical systems.

The second part of this project provides for further specific modifications to Pad A. During acoustic tests of the shuttle vehicle scale model at Marshall Space Flight Center, it was determined that launches will produce excessive acoustic levels. For that reason, a test program was initiated at MSFC, using an 8% replica of the shuttle, to determine the ground facility options available to alleviate this critical acoustic problem. Despite the fact that this test program is still underway and the test data is continuing to be analyzed, a "baseline" feasible solution has been identified. Refinement and optimization of this solution should be available in early CY 1976.

This "baseline" solution, stemming from the results of completed tests, indicate that a high pressure water injection system will reduce the acoustic levels which must be coped with. To meet these basic requirements, a water system has been sized at a flow capacity of 400,000 to 500,000 gallons per minute (1.5 to 1.9 million liters/min). The facilities required to achieve this attenuation capability will include new hydropneumatic storage tanks and new distribution piping and nozzle spray systems. The resultant new water injection system will be independent from the existing water "quench" system at the pad. This "baseline" solution, with certain optimization, is at present considered to be a satisfactory solution for solving the excessive acoustic problem up to "lift-off".

The scale model test program is continuing in an effort to further optimize this solution in terms of nozzle patterns and locations at the pad as well as to determine how these acoustic levels may be attenuated from "lift-off" to a point up to 5-7 seconds after launch. The scope of the facility modification to satisfy this further requirement is not defined at this time and funds are not included in this project for that extended requirement.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				19,855,000
Mobile launcher structural modifications	LS	---	---	9,400,000
Remove umbilical tower	LS	---	---	(1,650,000)
Modify mobile launch platform	Ton	2,500	3,100	(7,750,000)
Mobile launcher electrical modifications	LS	---	---	965,000
Mobile launcher mechanical modifications				4,490,000
Environmental control systems	LS	---	---	(1,160,000)
Propellant system	LS	---	---	(1,200,000)
Pneumatic systems	LS	---	---	(1,430,000)
Water systems	LS	---	---	(560,000)
Fire protection	LS	---	---	(140,000)
Pad A modifications	LS	---	---	5,000,000
Hydropneumatic storage tank	LS	---	---	(2,744,000)
Distribution system (piping, spray nozzle)	LS	---	---	(2,256,000)
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				19,855,000

LIST OF RELATED GRAPHICS:

Location Plan
Mobile Launcher Perspective

OTHER EQUIPMENT SUMMARY:

It is anticipated that approximately $3.7 million of R&D resources will be required to provide noncollateral equipment (platforms, access stands, tail service masts, solid rocket booster supports and holddowns) for initial operation of the mobile launcher.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

It is estimated that $43 million to $50 million from future CoF programs will be required to provide the additional launch facilities necessary to complete this project. These CoF funds will be used to modify another pad, two more high bays in the Vehicle Assembly Building, possibly a third firing room in the Launch Control Center, and to provide protection from lightning for the shuttle during transportation to the launch pad. With completion of the acoustic test program at Marshall Space Flight Center, the remaining modifications to Pad A will be required to solve the acoustic spectrum problem after "lift-off." This additional future requirement is estimated to be $3 million to $5 million and is included in the total requirement for Launch Complex 39 indicated above. Additional funds will also be required for modification of a third mobile launcher should this requirement be later validated for the increased flight rates and this is not included in the estimated future funding indicated above.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE:	Modifications for Solid Rocket Booster Processing Facilities
INSTALLATION:	John F. Kennedy Space Center
FY 1977 CoF ESTIMATE:	$9,700,000

LOCATION OF PROJECT: Kennedy Space Center and Cape Canaveral Air Force Station, Brevard County, Florida

COGNIZANT HEADQUARTERS: Office of Space Flight

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	1,870,000	5,240,000	7,110,000
Other affiliated funding	---	156,902,000 *	156,902,000
Total	1,870,000	162,142,000	164,012,000

* NOTE: Does not include costs for Air Force-owned facilities.

SUMMARY PURPOSE AND SCOPE:

This project continues modifications provided by the FY 1976 project for solid rocket booster (SRB) processing facilities. The FY 1976 project initially provided for modifying the existing Air Force Titan III Solid Motor Assembly Building (SMAB) to provide the capability to receive and process solid rocket motors and to assemble large SRB segments before they are moved to the NASA Vehicle Assembly Building (VAB) for stacking, mating, and integrating with the external tank and orbiter. Facility utilization changes in late CY 1975 consolidated these functions in the VAB in lieu of the SMAB. These changes were adopted based on favorable costs and operational benefits of the VAB versus the SMAB. This FY 1977 project provides for modifications to existing facilities at Kennedy Space Center (KSC) and Cape Canaveral Air

Force Station (CCAFS) required to support the essential functions of retrieving, cleaning, disassembling, refurbishing, and processing SRB components, parachutes, and associated hardware. The facilities to be modified include the Saturn dock, Hangar AF, and access between the dock and Hangar AF. The facilities to be modified at KSC include Building M7-657 and the VAB low bay area.

PROJECT JUSTIFICATION:

The shuttle vehicle consists of an orbiter, an external tank, and two solid rocket boosters. 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, a parachute recovery system, and attachment structures. After performing their intended function, the SRB's will be separated from the orbiter/external tank and descend, via parachutes, to a splashdown area in the ocean, where they will be recovered and returned to land for subsequent reuse. The recovered SRB's will be towed directly to CCAFS. Upon arrival at the existing Saturn dock, the SRB's will be removed from the water, "safed," and washed. The other recovered components will be unloaded from the retrieval vessel and processed at designated facilities. To achieve these vital recovery and retrieval operations, this FY 1977 project is required.

After recovery and cleaning, the SRB's will be transported on a dolly rail system into Hanger AF, where they will be disassembled into component subassemblies. The SRB casing will be prepared for shipment back to the Thiokol Corporation in Utah, where it will be reloaded with solid propellants. The remaining segments, including the forward skirt and the aft skirt, will be further disassembled into components and transported to the VAB low bay for maintenance, refurbishment, and reassembly for reuse. Refurbishment of the SRB parachutes will be separately accomplished in Bldg. M7-657 in the KSC industrial area. Here the parachutes will be defouled, washed, dried, repaired, and sent to the VAB for reassembly into the nose cone. The assembled components then will be transported to High Bay 4 of the VAB for final assembly into major assembly sections. To carry out these important disassembly and refurbishment operations, the proposed facility modifications are required.

An engineering analysis indicated that the use of existing Air Force and NASA facilities is an effective and economical solution to support the necessary and complex SRB processing operations. The alternative of constructing new facilities for these activities is estimated to cost more than twice the amount required for modifying existing facilities for the same purposes.

The first manned orbital flight is currently scheduled for the second quarter of CY 1979. To achieve this goal, SRB components should be delivered to Kennedy Space Center in the third quarter of CY 1978 for the start of the assembly operations. Disassembly and refurbishment facilities must be operational by the second quarter of CY 1979 to support the first manned flight. Consequently, the SRB processing facilities must be operationally ready by these dates to meet program requirements. Modification and activation

lead times, estimated at 26 to 30 months, require that construction be started in the fourth quarter of CY 1976, thus necessitating this FY 1977 programming.

PROJECT DESCRIPTION:

This project includes continuation and extension of the work begun in the FY 1976 project for the SRB processing facilities. The major work includes:

a. Recovery and Disassembly Facilities

Retrieved SRB's will be received at the Saturn dock, lifted from the water, and placed on cradle dollies. They will then be transported to an outdoor area for safing and then to an outdoor wash rack where insulation removal and initial cleaning will be accomplished. They will then be transported to Hangar AF where the SRB's will be disassembled and undergo final cleaning, and components readied for refurbishment. In order to accommodate these operations, the existing barge basin at the Saturn dock must be dredged to 12 feet (3.7 m) and enlarged. A slip and crane of approximately 120 tons (109 metric tons) capacity will be provided at the dock. A new dolly rail system to transport the SRB will be constructed from the slip to and through Hangar AF. An outside wash station which will house a high-pressure water and scrubbing system for washing and stripping insulation from components will be constructed. To provide a drying and preserving area, stripping stands, and work platforms in Hangar AF, utilities must be expanded and adequate drains provided to handle large amounts of water. Lighting, power, communication, fire protection, and air conditioning systems must also be modified and extended.

b. SRB Refurbishment and Subassembly Facilities

After operations in Hangar AF are complete, SRB components will be transferred to the VAB Low Bay for refurbishment and subassembly buildup. To accomplish these operations, the west side of the VAB low bay (cells 1 through 4) and adjacent rooms must be modified and outfitted. Modifications to cells 1 through 4 include removal of existing work stands; installing new specifically configured workstands for the aft skirt, forward skirt, and frustum; and providing four new cranes to service these stands. Existing utility systems must also be modified to support the refurbishment and subassembly buildup in this area. To support the required painting and insulation of components during the refurbishment operations the modifications will include: removing and installing partitions to create paint and insulation booths; addition of a heating system for curing processes; installing an air exhaust filtration system; and adding a breathing air system. Turntables will be installed in the paint and insulation area to provide rotation of the assemblies during automatic spraying operations for paint and insulation. Electrical power, lighting, sprinkler, communications, and alarm systems will also be modified in these areas. An area on the second floor of the low bay will be modified to support a mixing area required for the appli-

cation of insulations. These modifications will consist of partition changes; addition of an air exhaust filtration system; and installation of mixing equipment for the insulation.

c. Parachute Refurbishment Facilities

Building M7-657 located in the KSC industrial area will be modified and enlarged to receive, clean, refurbish, repack, and temporarily store retrieved parachutes. Building M7-657 is approximately 200 feet (61 m) long by 50 feet wide (15.2 m) and was originally designed as a parachute packing facility to support the Gemini program. The existing portion will be modified to perform parachute inspection and repair functions as well as to provide for equipment storage and administrative support. New construction consists of two additions to the facility, one 8,000 square feet (743 m^2) open addition and one 12,000 square feet (1,115 m^2) enclosed addition. Parachute defouling, washing, drying, packing, and storage functions will be performed in the new additions. A monorail system is necessary to provide parachute horizontal transportation and handling capability within the facility. A parachute washer and a parachute dryer will be constructed. Expanded utility systems will be provided and fire alarm, communications and air conditioning systems will be extended throughout the area.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				9,700,000
Recovery and disassembly facilities				5,030,000
Modify dock and slip	LS	---	---	(2,120,000)
Construct 120-ton crane	LS	---	---	(1,190,000)
Modify Hangar AF	LS	---	---	(1,300,000)
Cleaning system	LS	---	---	(420,000)
Refurbishment and subassembly facilities	LS	---	---	2,500,000
Work stand area	LS	---	---	(431,000)
Bridge cranes	EA	4	175,000	(700,000)
Paint and insulation area	LS	---	---	(1,369,000)

	Unit of Measure	Quantity	Unit Cost	Total Cost
Parachute refurbishment facilities.....	LS	---	---	2,170,000
Site preparation.....	LS	---	---	(145,000)
Architectural/structural.....	LS	---	---	(821,000)
Mechanical, electrical, utilities.....	LS	---	---	(646,000)
Wash and dry system.....	LS	---	---	(558,000)
Fallout Shelter (not feasible).....	---	---	---	---
Total.....				9,700,000

LIST OF RELATED GRAPHICS:

Location Plan at KSC
Location Plan at CCAFS
SRB Flow at KSC
Plan (SRB Recovery and Disassembly Facility)
Floor Plan (SRB Component Refurbishment and Subassembly)
Floor Plan (Parachute Refurbishment Facility)

OTHER EQUIPMENT SUMMARY:

It is estimated that approximately $12 million in R&D resources will be necessary to provide noncollateral equipment (transporters, dollies, pallets and canisters, handling equipment, and assembly kits) for this portion of the SRB processing facilities.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

For presently planned usage, there are no currently foreseen future CoF funding requirements necessary to complete this project.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE: Construction of Shuttle/Carrier Aircraft Mating Facilities

INSTALLATION: John F. Kennedy Space Center

FY 1977 CoF ESTIMATE: $2,050,000

LOCATION OF PROJECT: Merritt Island, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	546,000	8,090,000	8,636,000
Other affiliated funding	---	---	---
Total	546,000	8,090,000	8,636,000

SUMMARY PURPOSE AND SCOPE:

This project is a continuation and extension of the construction work to provide shuttle/carrier aircraft mating facilities. FY 1975 resources provided for long lead procurement of hoists and steel for the mating facilities at Flight Research Center (FRC), California, and at the orbiter assembly site at Palmdale, California; the access towway between the mating facility and the existing runway system at FRC; orbiter safing facilities; and associated utilities at FRC. The FY 1976 project provided for foundations and utilities at Palmdale, and the erection of mating facilities at both FRC and Palmdale. This FY 1977 project provides the required mating facility at Kennedy Space Center (KSC). This increment will complete all foreseeable requirements for mating facilities in support of the shuttle program.

PROJECT JUSTIFICATION:

The decision in early CY 1974 to transport and flight test the orbiter in a "piggyback" arrangement on top of a Boeing 747 aircraft resulted in the requirement to construct mating/demating facilities at Palmdale and FRC. This project provides the necessary comparable facility to transport the orbiter to and from the launch site.

The first orbiter is scheduled to arrive at KSC from Palmdale in the third quarter of CY 1978. The mating facility must be operable at that time to demate the orbiter safely from the Boeing 747 aircraft. Subsequently, two more orbiters will be received at Kennedy. In addition, the mating facility will be required to receive and demate the orbiter during the orbital flight test program. At least four orbital flights will land at FRC during this program. After each landing the orbiter must be transported via the Boeing 747 carrier aircraft to KSC for processing and relaunch. During the operational phase, two to three missions per year may land at the FRC alternate landing site. In each case, the orbiter must be returned to the launch site. It is also anticipated that the three orbiters stationed at KSC may occasionally have to be returned to Palmdale for overhaul or repairs. To support these operations, this mating facility at the launch site is required.

To achieve the first manned orbital flight, currently planned in the second quarter of CY 1979, the first orbiter must be delivered to KSC in the third quarter of CY 1978. The mating facility must be operational at that time to meet this milestone. Construction and activation are estimated to require 20 to 22 months. Therefore, construction must start in late CY 1976, making FY 1977 programming necessary.

PROJECT DESCRIPTION:

This project provides for the procurement, fabrication, and erection of a mating/demating facility at KSC, as well as the necessary site preparation, concrete slab, foundation, and utilities for the facility. It will be located at the south end of the orbiter landing facility near the junction with the orbiter towway.

The mating facility includes a structural steel, gantry-type, cantilevered structure approximately 100 feet (30.5 m) high, with movable platforms and a hoist capable of lifting approximately 225,000 pounds (102,060 kg). In order to support the structure, eight reinforced concrete footings, requiring approximately 330 cubic yards (252 m^3) of concrete, will be needed. A concrete slab 160 feet by 190 feet (48.8 m by 57.9 m) and 16 inches (40.6 cm) thick will support the mating/demating operations.

A 350-kVA, 480-V, 3-phase, 60-Hz industrial power circuit from an existing substation near the landing aids control building will supply electrical utilities to the facility. A direct burial cable will be

terminated in a safety switch adjacent to the concrete foundation. A grounding system to protect against lightning will be installed at the base of the facility. Area lighting will also be provided.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				2,050,000
Mating/demating facility	LS	---	---	1,718,000
Site preparation, utilities, slab, foundation and area lighting	LS	---	---	332,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				2,050,000

LIST OF RELATED GRAPHICS:

Location Plan
Photo: Shuttle/Carrier Aircraft Mating Facilities

OTHER EQUIPMENT SUMMARY:

For initial operations, it is estimated that approximately $50,000 of R&D resources will be required at KSC for noncollateral support equipment to demate the orbiter from the Boeing 747 aircraft.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

For presently planned usage, there are no currently foreseen future CoF funding requirements necessary to complete this project.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE:	Modifications for Crew Training Facilities
INSTALLATION:	Lyndon B. Johnson Space Center
FY 1977 CoF ESTIMATE:	$780,000

LOCATION OF PROJECT: Houston, Harris County, Texas

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	171,000	1,250,000	1,421,000
Other affiliated funding	---	10,206,000	10,206,000
Total	171,000	11,456,000	11,627,000

NOTE: Specific funding data applies to Bldgs. 5 & 29. Affiliated funding data applies to Bldg. 29 only.

SUMMARY PURPOSE AND SCOPE:

This project continues work begun with FY 1975 and FY 1976 funds to modify existing flight crew training facilities at Johnson Space Center. The FY 1975 project provided for modifications to Building 5 to accommodate the orbiter aeroflight simulator and the shuttle mission simulator computer. The FY 1976 project provided for further modifications to Building 5 to accommodate the shuttle mission simulator and associated visual scene generation system. This FY 1977 project provides modifications to Building 29, Flight Acceleration Facility, for a water immersion facility. This FY 1977 facility is required to provide the capability necessary for the adequate training of shuttle crews and mission specialists in an environment closely simulating the weightless conditions of outer space.

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PROJECT JUSTIFICATION:

A key factor in the success of the manned space flight program to date has been the intensive flight crew training using mission simulators. Existing training facilities at Johnson Space Center have been specifically constructed and successfully used to support training for Gemini, Apollo and Skylab. These facilities can be modified to support training for shuttle missions.

This project will provide the capability to train space shuttle flight crews to perform extra-vehicular activities in a weightless environment. Flight crews must be trained to perform certain activities outside the spacecraft during a mission. It will be necessary, for example, to adjust instruments, check experiments, retrieve and replace film, or service satellites. These and similar activities will be scheduled before a mission begins. It is also necessary for crews to know how to cope with unscheduled problems that may arise outside the spacecraft such as assessing damage to the spacecraft or payload, repairing damaged components and rescuing stranded crews. As the Skylab program demonstrated, crews can handle many repairs outside the spacecraft if they have been properly trained. In this instance, that training, to a large extent, proved most important to the successful completion of the Skylab program.

Experience has shown that training crews for these activities in water most closely simulates the weightless environment of outer space. A water immersion facility, such as the one this project provides at Johnson Space Center, will help crew members better learn how to handle tools and equipment so as to work more effectively in outer space. It will also aid in compiling crew instruction manuals as procedures for performing tasks in a weightless environment are developed.

The water tank, which will be used for training for the duration of the shuttle program, must be large enough to accommodate shuttle test training articles such as the payload bay, airlock and the crew module simulators. Although an existing tank at Marshall Space Flight Center (MSFC) is adequately sized, the results of reviews have shown that using the MSFC facility would be more expensive than providing a water immersion facility at JSC, where most of the other crew training takes place. Extensive modifications would be required to the building housing the tank at MSFC. Although the facility modification at MSFC would initially cost less than the proposed facility at JSC, the cost of transporting approximately 5 - 7 trainees and support personnel per week, associated per diem expenses, the cost of training time lost, as well as the added equipment and manpower requirements, would offset the initial facility cost difference in two to three years of space shuttle operations. In addition, fragmenting crew training activities at two sites would tend to degrade the quality and effectiveness of implementing integrated crew training plans and would most likely have an adverse effect on the flight schedules.

The water immersion facility must be operational at least one year before the first manned orbital flight which is currently scheduled for the second quarter of CY 1979. The full-scale orbiter payload trainer is scheduled to be delivered in early CY 1978. Construction and activation will require approximately 15 to 18 months and must begin in late CY 1976, thus necessitating FY 1977 funding.

PROJECT DESCRIPTION:

This project includes modifications to Building 29, the Flight Acceleration Facility, to provide a water immersion facility required for training shuttle flight crews and mission specialists. The Flight Acceleration Facility is primarily a centrifuge rotunda with two attached support wings. A concrete and steel rectangular water tank with interior dimensions of 30 feet by 78 feet by 25 feet deep (9.1 m by 23.8 m by 7.6 m) will be constructed inside the existing centrifuge rotunda building. The concrete portion of the tank will be recessed 15 feet (4.6 m) below the ground floor level. The upper 10 feet (3.0 m) will be of steel construction. A series of lighting portholes with associated 1,500-watt lamps, viewing portholes, and a ladder will be installed in the tank walls. A new 560-gallon per minute (35.3 liter per second) water treatment plant with associated filters and heating system will be installed. A platform will be constructed around the top of the tank and will be connected, by a ramp, to the existing second floor control room in one of the support wings. A sump pump and motor will be located in a pit adjacent to the tank. Drainage of the tank will be through the existing storm drains.

A partition will be constructed across the rotunda to separate the tank from the existing centrifuge, which will remain in place. The steel walls and platforms of the tank will be removable to permit operation of the centrifuge if this becomes necessary.

Maximum use will be made of existing facilities and equipment at the Johnson Space Center to provide an operable crew training facility. Existing facilities that will be used with little or no modification include: a test control center, locker room, visitors viewing room, work and administrative space and shower facilities that are located in the support wings of Building 29. The existing equipment includes a five ton crane with monorail, environmental control consoles, breathing air system, a hyperbaric chamber and related instrumentation and control system. The project provides for relocating and installing this equipment within this facility. Associated utility modifications and extensions will also be made.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				649,000
Demolition, excavation, piling and foundations	LS	---	---	253,000
Tank, concrete and steel with portholes	GAL	420,000	0.42	176,000
Platforms, ladders, rails and ramp	LS	---	---	75,000
Partitions	SF	5,000	5.00	25,000
Electrical and mechanical utilities	LS	---	---	120,000
Equipment				131,000
Water heat and treatment plant	GAL	400,000	0.22	88,000
Installation of existing equipment	LS	---	---	43,000
Fallout Shelter (not feasible)	---	---	---	---
Total				780,000

LIST OF RELATED GRAPHICS:

Location Plan
Floor Plan

OTHER EQUIPMENT SUMMARY:

Existing collateral and noncollateral equipment at Johnson Space Center, estimated at a replacement value of approximately $210,000, will be used to make the facility operable. This equipment includes a hoist,

crane, air compressor, portholes, hyperbaric chamber, television cameras, test instrumentation, and control consoles. In addition, orbiter trainers estimated to cost $3.7 million and to be acquired from space shuttle R&D resources will be required for the initial operation.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

There are no foreseeable future CoF funding requirements necessary to complete this project.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE:	Rehabilitation and Modification of Shuttle Facilities
INSTALLATION:	Various Locations
FY 1977 CoF ESTIMATE:	$1,760,000

LOCATION OF PROJECT: Various Locations

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to prior shuttle unique rehabilitation and modification projects:

	Planning and Design	Construction	Total
Specific CoF funding	138,000	210,000	348,000
Other affiliated funding	---	---	---
Total	138,000	210,000	348,000

SUMMARY PURPOSE AND SCOPE:

The purpose of this project is to provide for the minor rehabilitation and modification of facilities required to support the Space Shuttle Program at NASA field installations and Government-owned industrial plants. Included in this project are facility rehabilitation and modification needs which are estimated to cost less than $500,000 per project and are uniquely required by the shuttle program to achieve initial operational capability; to meet program milestones or "need dates"; or to ensure compliance with pollution, safety, or health regulations or standards at facilities the implication of which will directly relate to shuttle operations.

PROJECT JUSTIFICATION:

The space shuttle development, assembly, and test requirements are being carried out to a large extent in existing Government facilities at the various NASA installations and industrial plants. The major modifications and new construction required at these various locations have been presented in past fiscal years as discrete line items within an integrated space shuttle facilities project. In many instances, the existing facilities either have the necessary capability or require only limited rehabilitation or relatively minor modifications to achieve the capability for the desired tests in support of shuttle. For clarity, full disclosure purposes, and better fiscal and technical control, all unique space shuttle facility requirements, both discrete individual line item projects as well as the smaller facility projects, are included within the integrated total space shuttle facility program.

This project includes only shuttle-unique facility rehabilitation and modification work at various locations, each item having an estimated cost not in excess of $500,000. Each work item is necessary to support a specific shuttle requirement, ensure continued reliability, provide a safer environment, and/or improve the efficiency and economy in individual facilities supporting the Space Shuttle Program.

The work covered in this project is of such a nature and magnitude that it is considered best to include these requirements under a single rehabilitation and modification shuttle project for various locations. The cost of this project and all such follow-on projects will be charged against the total space shuttle facility "run-out" costs previously estimated at $300 million (1971 dollars). This total remains a valid maximum cost for the facilities required by the shuttle program.

PROJECT DESCRIPTION:

This project provides for necessary rehabilitation and modifications to existing facilities in support of the Space Shuttle Program. The justification, description, and cost estimate for each element are listed below:

A. Johnson Space Center	660,000
1. Modifications for Flash Evaporator Testing, Building 7	220,000

This project provides for modifying the existing vacuum system associated with the 11-foot (3.4 m) chamber in Building 7. The work is required to support the orbiter's flash evaporator test to be carried out in an adjacent 8-foot (2.4 m) chamber. The flash evaporator is a flight component of the Environmental Control and Life Support System contained in the shuttle crew module. It provides for the necessary cooling to the orbiter systems at altitudes

above 100,000 feet (30,480 m) when the radiators are not operative. Verification and acceptance testing of this hardware item, scheduled to start in the second quarter of CY 1977, is essential for the safety and success of the mission. The modifications include procuring and installing two 12-inch (30.5 cm) cold traps for water vapor removal, relocating the 8-foot (2.4 m) chamber, and interconnecting this chamber with the modified vacuum system. The work also includes the installation of a vapor ventilator into the roof, and a water drain line from the cold traps into the floor of Building 7. Automatic controls to operate the valves of the vacuum system are also included.

2. Modifications of Mission Control Center, Building 30 — 150,000

This project provides for various modifications to the mission operations wing of Building 30 to prepare for the establishment of the shuttle data processing complex. The shuttle data complex will use a new generation computer that will replace most of the functions now being carried out by the existing real time data processing system. The data complex and related facility modifications are required to provide real time flight data evaluation and mission control during the approach and landing test and orbital flight test phases of the shuttle program. To accommodate the new equipment, modifications to the electrical power system, reconfiguration of raised flooring, and modification of overhead and underfloor air conditioning will be required. The first computer for the new data processing complex is planned for installation in mid-1977; modifications to accommodate this computer must, therefore, be completed before that date.

3. Rehabilitation and Modification of Test Facilities, Thermochemical Test Area — 290,000

It is necessary that these test facilities be rehabilitated and upgraded at this time to support a range of essential test activities currently being conducted for components of the orbiter vehicle. These activities include developing and test firing of the vernier thrusters, a subsystem of the reaction control system (RCS) required to provide precision in the attitude control of the orbiter vehicle. Also included is testing of pyrotechnic devices essential in separating the solid rocket boosters and the external tank, battery systems for providing power, and testing the RCS components. The work includes installing an emergency propellant tank to retain and safely dispose of hazardous fuels at the component test facility, modifying the ventilation system to safely dispose of hydrogen gas in the battery testing facility, rehabilitating the altitude chamber system in the RCS test facility, and interconnecting by data cables the Electro-Explosives Device Building with an existing computer located within the Thermochemical Test Complex.

B. NASA Industrial Plant, Downey - Dual Fuel System Conversions — 210,000

This project provides for modification of several systems at the NASA Industrial Plant to accommodate alternate energy sources to back up the existing natural gas fueled systems. Past mid-winter natural gas curtailment and interruptions dictate the need to install redundant systems to preclude resultant work stoppages that could effect space shuttle manufacturing milestones. For example, during 1974 and 1975, this plant experienced five days of interrupted natural gas service each year. It is anticipated that the frequency and duration of such outages may well continue to increase in the future. This project will permit continuation of operations at Downey in the event of significant natural gas curtailment or interruption.

The project includes: the addition of a fuel oil capability for one oven and two autoclaves in Building 287; addition of a steam heat capability to augment gas-fired temperature and humidity control in the paint spray booth in Building 041; and the addition of approximately 90 electric space heaters in several buildings at the NASA Industrial Plant to augment the existing gas-fired space heaters to assure minimum personnel comfort levels in the event of natural gas curtailment. These alternate heat sources must be installed before frequent curtailments of natural gas service occur.

C. Michoud Assembly Facility (MAF) — 430,000

1. Rehabilitation of Chemical Waste Pond — 75,000

This project consists of rehabilitating surface lift pumps, replacing deteriorated filters, cleaning, and resurfacing the 1,500,000-gallon (5,677,950 liter) chemical waste holding pond. This pond is the only means of disposing of chemical waste from manufacturing operations at MAF. This holding pond has been used for 12 years, its pumps and filters for almost 10. The bottom has deteriorated to the extent that chemical wastes can seep into the ground water. Temporary measures are now being taken to preclude contamination. However, the pond must be rehabilitated and upgraded before external tank production begins. The pond rehabilitation will alleviate the existing adverse effects on MAF's environment.

2. Rehabilitation of Road for Movement of External Tanks — 170,000

This project consists of repairing 14,165 square yards (11,843 m^2) of concrete aprons west of Building 103, resurfacing 12,555 square yards (10,497 m^2) of asphalt roads and aprons to Building 420, and providing an asphalt ramp into Building 420. The existing road and apron

surfaces have deteriorated and could, therefore, damage the shuttle external tanks during transportation from one area to another. The rehabilitated ramp will provide smooth transport from grade level to the floor level of Building 420, which is now approximately 8 inches (20.3 cm) above grade. This work must be accomplished by early CY 1977 to support production of the external tank structural test article.

3. Modifications of Fuel Oil Supply System 185,000

This project provides for the installation of 1,200 feet (365.8 m) of 4-inch (10.2 cm) pipe and attendant supports to transfer oil from a 500,000-gallon (1,892,650 liter) storage tank to two day tanks outside the boiler house. The project also provides for installing a transfer pipe from a fill station at a railroad siding to the 500,000 gallon (1,892,650 liter) tank. The work is necessary to provide a back-up system of generating steam for MAF, which presently uses natural gas as the primary heating fuel. If the supply of natural gas is interrupted, the entire production program would be shut down. This project provides the necessary oil distribution system to ensure uninterrupted production operations in the event the natural gas supply is temporarily stopped. In light of the current energy crisis, it is prudent to accomplish this work in this time frame.

D. Flight Research Center (FRC) - Modification of Approach and Landing Test (ALT) Hangar 460,000

This project includes installing an air handling system in the ALT hangar to provide a clean and partially controlled environment during payload handling operations following the return of the space shuttle orbiter from space missions. The clean environment is required to prevent contamination of sensitive payloads returned from a space mission. At least four of the first six orbital missions of the space shuttle are scheduled for landing at FRC. Thereafter, FRC will become the secondary landing site for the orbiter. During the operational phase, two to three secondary landing site missions per year may have to land at FRC. After landing, the orbiter's environmental support system will no longer provide the necessary environment to the payload bay. For this reason, payloads must be removed from the orbiter and prepared for shipment. These payload handling operations must be conducted in an acceptably clean environment to protect the components and experiments in which significant investments have been made. The air handling system will include blowers of up to 250,000 CFM (7,080 m^3/min) capacity, with associated particulate air filters, limited cooling to offset heat rise of the recirculated air, a 1,000-foot (304.8 meters) ducting system and related switches and controls. These modifications, to be implemented before the first manned orbital flight, must be phased in such a way as to preclude interference with the orbiter approach and landing test program.

PROJECT TITLE:	Modification of Manufacturing and Final Assembly Facilities for External Tanks
INSTALLATION:	Michoud Assembly Facility
	FY 1977 CoF ESTIMATE: $1,930,000

LOCATION OF PROJECT: New Orleans, Orleans Parish, Louisiana

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

COGNIZANT INSTALLATION: Marshall Space Flight Center

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	1,788,000	14,522,000	16,310,000
Other affiliated funding	---	158,241,000	158,241,000
Total	1,788,000	172,763,000	174,551,000

SUMMARY PURPOSE AND SCOPE:

This project continues the work begun with FY 1973 and FY 1974 resources to modify manufacturing and final assembly facilities for shuttle external tanks at Michoud Assembly Facility. These prior year resources provided modifications to the Main Manufacturing Building (Building 103) for welding, mechanical subassembly, and final assembly facilities to produce the liquid hydrogen tank, the liquid oxygen tank, and the intertank which comprise the external tank. They also provide a new facility for the pneumatic testing of the liquid hydrogen tank. In the Vertical Assembly Building (VAB), prior resources provided for modifying five cells -- one for hydrostatic testing, one for cleaning tank components, one for stacking

the three major components into a complete external tank, and two for applying the thermal protection system (TPS) to the surface of the tanks.

These projects were intended to meet the requirements for external tank development and for initial production capability of up to 24 to 28 tanks per year. The results of a recent analysis have shown, however, that this capability cannot be met in the TPS application area. This year's project provides modifications for an additional cell in the VAB to apply the TPS to the external tanks. This work includes constructing a concrete silo and foundation, and installing various mechanical and utility systems.

PROJECT JUSTIFICATION:

The external tank, which supplies propellants to the orbiter main engines, is approximately 27.5 feet in diameter by 153.7 feet long (8.4 m by 46.8 m). It is composed of a liquid oxygen tank and a liquid hydrogen tank connected by an intertank. Two kinds of TPS are needed to cover the tank -- one (the foam insulation) because of the extremely cold temperatures of the propellants and one (the ablator) because of the extremely high temperatures encountered during launch and ascent of the shuttle. It was initially estimated that FY 1973 and FY 1974 resources would provide the capability to produce 24 to 28 of these tanks per year at MAF. The thermal protection system was to be applied in two modified cells in the VAB.

Since this original planning, three major problems -- icing, aerodynamic heat, and base heat -- have emerged, requiring changes in the TPS configuration. Tests have shown that ice or frost may develop on the exterior surface of the tank, chip off, and damage the orbiter. Spraying the tank with foam insulation will eliminate this problem. Wind tunnel tests have also shown that the problem of aerodynamic heat encountered during launch is much more severe than had been expected. Ablator application will correct this problem. A combination of ablator and spray-on foam insulation will protect the tank from both extreme cold and extreme heat. The portion of the external tank adjacent to the solid rocket boosters is subject to extremely high temperature during ascent firing of the orbiter. Therefore, an ablator is also needed to protect the base of the external tank.

There are thus two kinds of TPS to be applied to the external tank; some areas require either foam or ablator and others require both. The two materials cannot physically be applied at the same time; furthermore, they are chemically incompatible in the liquid form. Therefore, the same cell cannot be used for applying both kinds of thermal protection. The two materials must be segregated during application to ensure proper adhesion of the foam on areas which otherwise would require an elaborate intermediate cleaning and priming process.

Because of these problems, the TPS area is now the only phase of external tank production that cannot support a production rate of at least 24 to 28 tanks per year. The two existing TPS cells can be used for the application of foam insulation, but modification of a third cell for the application of ablator is needed. This additional cell will support the dual TPS application needed to produce 10 to 14 tanks per year by 1981.

This cell is needed by early 1978 to support the initiation of the work of applying ablator to components of the external tank needed for the first manned orbital flight, currently scheduled for the second quarter of CY 1979. The tanks for the shuttle test program are not a factor in this requirement because they only need foam insulation and do not need the dual TPS application. Construction and checkout of this work will require approximately 13 months, beginning late in CY 1976. This project thus requires FY 1977 funding.

PROJECT DESCRIPTION:

This project, to support the production of 10 to 14 external tanks per year, provides modifications to cell D in the Vertical Assembly Building for TPS application. A 45-foot-inside diameter by 119-foot-high (13.7-m by 36.3-m) concrete silo with a mechanically operated lid will be constructed. A pile-and-concrete foundation to support the silo will be provided. Work platforms, stairways, and doors will be installed, and various mechanical systems such as air conditioning, fume abatement, fire detection, sprinkler and vacuum as well as utility systems will be provided.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				1,909,000
Concrete silo structure	CF	189,238	2.90	549,000
Foundation	LS	---	---	140,000
Work platforms, stairways, doors	LS	---	---	313,000
Air conditioning, fume abatement, fire detection and sprinkler, vacuum systems.	LS	---	---	697,000
Utility systems	LS	---	---	210,000

	Unit of Measure	Quantity	Unit Cost	Total Cost
Equipment				21,000
Transformers	EA	3	7,000	21,000
Fallout Shelter (not feasible)	---	---	---	---
Total				1,930,000

LIST OF RELATED GRAPHICS:

Location Plan
Site Plan and Section Plan

OTHER EQUIPMENT SUMMARY:

An estimated $100,000 in R&D funds will be needed for new noncollateral plant equipment. In addition, certain special noncollateral tooling (such as spray tooling, assembly tooling, unique work platforms, and special dollies) estimated to cost $2.3 million will be needed. It is planned to use existing Apollo tooling, with modifications as required, to the maximum possible extent to offset this estimated amount. The balance will be R&D funded.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

It is estimated that $12 million to $15 million will be required in a future CoF program to support a production rate of up to 60 external tanks per year. These CoF resources would be used to provide a high-bay building with additional TPS application cells, additional production cells for horizontal installation of the mechanical and electrical systems of the external tank in Building 103, an existing cell for final acceptance of the external tanks in Building 420, installation of an additional crane in Building 110, additional deionized water storage for cleaning the tanks, and a new chemical waste system for disposing of the increased quantities of chemicals during the manufacturing operations of the external tank. Additional storage space for the completed tanks may also be required. This upward revision of estimated future year CoF resources reflects the recently expanded requirements for TPS application as outlined in this project justification.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE:	Modifications to Operations and Checkout Building for Spacelab
INSTALLATION:	John F. Kennedy Space Center
	FY 1977 CoF ESTIMATE: $3,570,000

LOCATION OF PROJECT: Merritt Island, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	231,000	---	231,000
Other affiliated funding	---	42,691,000	42,691,000
Total	231,000	42,691,000	42,922,000

SUMMARY PURPOSE AND SCOPE:

The purpose of this project is to modify the existing Operations and Checkout (O&C) Building at Kennedy Space Center to accomplish pre-flight and post-flight processing of Spacelab and Spacelab payloads. The project includes modifying portions of the high and low bays of the building and providing work stands. These modified high and low bays, several rooms in the O&C Building, and the monitor and test control area will be used to receive, store, inspect, assemble, checkout, integrate, and refurbish the Spacelab hardware.

PROJECT JUSTIFICATION:

The space shuttle is only one part of the total space transportation system, which also includes Spacelab and the Tug. Spacelab is an experiment carrier being developed and paid for by the European Space Agency. It will provide crew accommodations, mounts for experiments, and support systems. Individual experiments will use the Spacelab as a platform to perform missions in space while still attached to the orbiter cargo bay. The orbiter will thus move through space with its payload bay doors open. Approximately one third of the payload missions planned for space shuttle operations will use Spacelab.

Spacelab payloads will be developed by various NASA centers as well as by private industry, universities, and government laboratories, both foreign and domestic, and then shipped to the launch site. In most cases, experiments will be mounted on pallets or racks before shipment to the launch site for final integration. Upon arrival at the O&C Building, individual experiments mounted on a single pallet segment or in a single rack will be received, inspected for damage and then integrated with other pallet segments and racks. These pallets and racks will then be integrated with a simulator of the Spacelab subsystems for initial checkout. Then the complete pallet train and the combined experiment racks will be integrated with the operational subsystems of the Spacelab and tested using simulated Shuttle subsystems. These integration operations will be accomplished in specially constructed workstands. The proposed facility modifications are necessary to provide for these essential operations.

After the Spacelab operational elements and the payload bay are assembled, integrated checkout operations follow. Pressure and leak checks are performed, and all interfaces are verified to ensure compatibility with each other and with the orbiter payload bay. Electrical integrity tests are accomplished with support equipment. The weight and balance of the Spacelab will be determined before it is loaded onto the transporter for delivery to the Orbiter Processing Facility (OPF), where only final Spacelab-to-Orbiter integration occurs. This project provides the needed modifications to achieve these vital Spacelab checkout operations before launch.

When the orbiter returns from a mission, the O&C Building will be used to disassemble and process Spacelab after it has been removed from the orbiter in the OPF. Spacelab payloads will be disassembled and returned to the center of origin. The operational Spacelab elements will remain in the O&C Building for refurbishment for the next Spacelab mission. To accomplish the disassembly and refurbishment functions, modifications to the existing O&C Building are required.

The first Spacelab orbital flight is currently scheduled in late CY 1980. To achieve this goal, program schedules call for the O&C Building to be operationally ready to support delivery of Spacelab engineering model hardware in mid-CY 1978. Facility modifications and activation lead times, estimated at 18 to 21 months, require that construction be started no later than the fourth quarter of CY 1976, thus necessitating FY 1977 programming.

PROJECT DESCRIPTION:

This project provides for modifying the existing O&C Building to process Spacelab and Spacelab payloads. In so doing, certain Apollo stands and equipment will be removed from the low bay. The cleaning area in the high bay will require exhaust fans for dissipating fumes accumulated during cleaning operations. Modifications in the assembly and test area include providing three assembly and checkout workstands and subsidiary stands for pallets, racks, end cones and cable refurbishment. Foundation reinforcement for these stands, reinforcement of an existing tunnel, and construction of new utility serviceways are also required. Additional interfaces for fluids and gases, new AC and DC power distribution, and cableways will be provided. Modification of crew compartment air and avionics cooling, and additions to the operational-voice intercom systems are necessary. Demolition and construction activities in this area will require refurbishment of the floor.

Existing doors and the laminar-flow clean room in the shipping, receiving and storage area of the low bay must be enlarged, and the existing monorail relocated. Modification work in the monitor and test control area consists of removing equipment and cables, modifying and repairing floors, modifying the air ducts, and installing partitions.

Fire protection and safety modifications consist of adding suppression systems in the shipping and storage area south of the low bay and in the tunnel that runs parallel with the low bay. Additional detection systems are required in the high and low bays. A fire suppression system will be added in the monitor and test control area.

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PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				3,570,000
Modify assembly and test area				2,916,000
Structural	LS	---	---	(670,000)
Mechanical	LS	---	---	(269,000)
Electrical/communication	LS	---	---	(760,000)
Fire protection	LS	---	---	(247,000)
Assembly and checkout stands	EA	3	290,000	(870,000)
Rack and pallet assembly stands	LS	---	---	(100,000)

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	Unit of Measure	Quantity	Unit Cost	Total Cost
Modify shipping, receiving, and storage areas				590,000
Remove existing equipment	LS	---	---	(180,000)
Structural	LS	---	---	(260,000)
Mechanical	LS	---	---	(40,000)
Fire protection	LS	---	---	(110,000)
Modify laboratories and support areas				64,000
Electrical	LS	---	---	(64,000)
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				3,570,000

LIST OF RELATED GRAPHICS:

Location Plan
O&C Building Perspective

OTHER EQUIPMENT SUMMARY:

Certain noncollateral equipment, to be funded from R&D resources, will be required to support initial operation. The kind, size and cost estimate for such equipment are not yet determined.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

An additional work area may be required to support higher shuttle flight rates and/or any additional processing tasks which may later be required at KSC. The scope of such work and its requirement cannot be validated at this time.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE:	Modifications and Addition for Shuttle Payload Development
INSTALLATION:	Goddard Space Flight Center
FY 1977 CoF ESTIMATE:	$770,000

LOCATION OF PROJECT: Greenbelt, Prince Georges County, Maryland

COGNIZANT HEADQUARTERS OFFICE: Office of Space Science

FY 1976 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF Funding	71,000	---	71,000
Other affiliated funding	---	9,666,000	9,666,000
Total	71,000	9,666,000	9,737,000

SUMMARY PURPOSE AND SCOPE:

The purpose of this project is to provide the space for developing, assembling, integrating, and testing GSFC-managed "free-flyer" shuttle payloads, using a multimission modular spacecraft. Approximately 6,300 square feet (585 m^2) of space in two buildings will be modified. New construction includes a 1,050-square foot (98 m^2) truck airlock. Another 4,100 square feet (381 m^2) of existing space will be used but does not require modification.

PROJECT JUSTIFICATION:

Goddard Space Flight Center (GSFC) is one of the leading NASA Centers in the development of earth applications, communications, and astronomical satellites. The development of about 40% of NASA

scientific satellites to date has been managed by GSFC. This project will adapt existing facilities to permit continuation of this work to support payloads flown during the shuttle era. The work performed in these facilities is essential to the achievement of NASA overall payload objectives.

The payload baseline calls for development of a multimission modular spacecraft (MMS). Development of this spacecraft is baselined to be accomplished in-house at GSFC and will be used for a number of currently planned earth orbital missions. The schedule for the design and development of this "free-flyer" spacecraft dictates that facilities be available in mid-CY 1978, thus requiring FY 1977 funding.

An engineering study has shown that existing facilities at GSFC, with certain modifications and additions, will be capable of meeting the payload development and validation requirements during the space shuttle era. The facility modifications planned are primarily required to accommodate the larger payloads and be responsive to the impact of the space shuttle flight environment. Based on this engineering study, which focuses on making maximum use of existing capabilities, the following specific facilities will be used to accomplish the development, integration, and validation functions for the GSFC scientific and technological payloads.

Building 22 will be used to develop and test the flight structure of "free-flyer" multimission spacecraft. It will also be used to assemble and check out flight support systems for the resupply and reservice of "free-flyers". The modifications are required to accommodate the larger size "free-flyer" spacecraft which has a basic support structure and four subsystem modules. These modules are equivalent in size to four smaller spacecraft.

Building 15 will be used to carry out dynamic and acoustic tests to verify the structural integrity of the payloads and their ability to withstand the dynamic forces encountered throughout the flight mission. For the qualification of the spacecraft structure, no suitable acoustic test facilities are available at GSFC to test the complete multimission spacecraft configuration in the shuttle acoustic environment. The proposed modifications to Building 15 will provide this capability at GSFC.

Building 11 will be used to integrate the mission experiments to the multimission spacecraft and accomplish the necessary system level testing. This facility requires no modifications to carry out the planned functions.

These facilities must be operational approximately 12 to 18 months before the payloads are flown to permit time for development, testing, and integration. The first such payload planned to use the MMS is the Solar Maximum Mission (SMM) which is composed of a coordinated set of experiments designed to investigate solar flare emissions and their effects at various wavelengths, as well as solar terrestrial relations. This mission is scheduled to fly in late CY 1979. To support this milestone, the facilities must be completed by mid-CY 1978. Construction and activation lead times are estimated at 18 to 20 months, thus requiring a construction start in FY 1977.

PROJECT DESCRIPTION:

In order to provide these payload facilities at GSFC, modifications to Buildings 22 and 15 will be required. Appropriate extensions to and modifications of utility, nitrogen, compressed air, and hydraulic systems will be provided as needed.

Building 22. Approximately 3,600 square feet (334 m^2) of space in Building 22 will be modified. An existing 12-foot x 12-foot x 60-foot long (3.7 m x 3.7 m x 18.3 m) solar array illuminator currently located in Building 22 will be dismantled and relocated, and a class 100,000 clean environment with controlled variable lighting will be provided in the facility. A truck airlock to prevent area contamination and to maintain positive pressure will be provided. Handling capability will be improved by replacing the existing crane with two 7.5 ton (6,804 kg) bridge cranes.

Building 15. Approximately 2,700 square feet (251 m^2) of the rotunda area of Building 15 will be modified. A reverberant chamber providing for shuttle acoustic spectrum test levels of 150 dB (qualification level) will be installed. It will be constructed of demountable reinforced concrete panels. An existing horn and horn support structure will be used in the chamber. An existing low-frequency vibrator will be relocated from the high bay of Building 15 to below grade within the reverberant chamber area. A 7.5 ton (6,804 kg) bridge crane will also be provided.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Cost	Total Cost
Land Acquisition	---	---	---	---
Construction				510,000
Building 22:				130,000
Relocation of solar array illuminator	LS	---	---	(5,000)
Modifications	SF	3,600	20.00	(72,000)
Truck airlock addition	SF	1,050	50.00	(53,000)

	Unit of Measure	Quantity	Unit Cost	Total Cost
Building 15:				380,000
Modifications	SF	2,700	20.00	(54,000)
Reverberant chamber	LS	---	---	(326,000)
Equipment				260,000
7½ ton bridge cranes	EA	3	80,000	240,000
Relocation and installation of existing vibrator and horn	LS	---	---	20,000
Fallout Shelter (not feasible)	---	---	---	---
TOTAL				770,000

LIST OF RELATED GRAPHICS:

Location Plan
Plan Building 22
Plan Building 15

OTHER EQUIPMENT SUMMARY:

No new noncollateral mechanical and electrical equipment is planned to make the facilities operational. Existing noncollateral equipment, valued at approximately $2,300,000, will be used in these facilities.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

Additional facility area will be required for shuttle payload integration, development, and verification. The need and scope of work required will be submitted in a follow-on program (FY 1978).

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

REHABILITATION AND MODIFICATION

Summary of Project Amounts by Location:	Amount	Page No.
Ames Research Center	1,410,000	CF 10-3
Flight Research Center	265,000	CF 10-5
Goddard Space Flight Center	1,345,000	CF 10-5
Jet Propulsion Laboratory	1,670,000	CF 10-8
Johnson Space Center	1,200,000	CF 10-10
Kennedy Space Center	1,190,000	CF 10-12
Langley Research Center	1,840,000	CF 10-14
Lewis Research Center	1,275,000	CF 10-16
Marshall Space Flight Center	1,515,000	CF 10-17
Michoud Assembly Facility	525,000	CF 10-20
National Space Technology Laboratories	905,000	CF 10-20
Wallops Flight Center	1,315,000	CF 10-22
Various Locations	1,820,000	CF 10-23
Miscellaneous Projects Less than $100,000 Each	1,600,000	CF 10-25
Total	17,875,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE: Rehabilitation and Modification of Facilities Not in Excess of $500,000 Per Project		
LOCATION: Various Locations		
	FY 1977 CoF ESTIMATE: $17,875,000	
FY 1975: $14,900,000	FY 1976: $16,000,000	TQ: $7,000,000

COGNIZANT INSTALLATION: 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 1977 which can be foreseen at the time of the submission of these estimates, and which are estimated not to exceed $500,000 per project. The purpose of this program is to protect, preserve, and enhance the capabilities and usefulness of existing NASA facilities, and to ensure the continued safe, economical, and efficient use of the physical plants. This year in addition to the usual rehabilitation and modification requirements to the physical plant, the agency has initiated specific procedures which place increased emphasis on the identification of projects which relate directly to the conservation of energy at the various field installations. These projects along with the installation of automatic utility control systems, account for a greater portion of this total program than in prior years. Current projections indicate that such projects will ensure significant and rapid "payback" in energy consumption and that the utility control system efforts will permit reductions in operating personnel. In the past, this particular program was specifically directed toward the general nonprogrammatic segments of NASA facilities, however increasing 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, 1975). 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. Ensure the continued and reliable availability of these facilities as well as their operational capabilities as applicable.

c. Improve the capabilities and usefulness of these facilities in terms of NASA mission accomplishment, and to overcome the aggregate effects of obsolescence.

d. Provide a better and safer environment for all personnel.

e. Provide for significant reductions in energy consumption through the initiation of energy conservation projects and the provision of updated and improved utility control systems.

This 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 1977. Provision for the major portion of this latter requirement is made under a separate project entitled "Minor Construction" which is included in the CoF estimates.

PROJECT DESCRIPTION:

Proposed rehabilitaiton and modification items for FY 1977 are outlined under "PROJECT COST ESTIMATE" and total $17,875,000. Of this total, $16,275,000 represents discrete work packages at designated NASA installations. The remaining $1,600,000 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 $54 million. This listing 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.

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 $16,275,000 of discrete projects relates to the following broad categories of facilities:

a. Utility Systems	4,740,000
b. Fire Detection/Protection Systems	1,010,000
c. General Purpose Buildings	4,940,000
d. Technical Buildings/Structures	3,915,000
e. Pavements and Drainage	990,000
f. Building Exteriors and Roofs	680,000

In addition, there is the "Lump Sum" estimate of $1,600,000 for smaller project work, thus making a total of $17,875,000. The FY 1977 requests for facility rehabilitation and modification work, which is essentially at recent prior year levels, are directed toward the most urgent current needs for work of this type in the continuation of this program at NASA installations.

PROJECT COST ESTIMATE:

A. Ames Research Center 1,410,000

1. Rehabilitation and Modification of 12-Foot Wind Tunnel, Building N-206 415,000

This project provides for certain rehabilitation and modification of the model support system in the 12-foot Wind Tunnel, Building N-206, and its associated systems. The upstream model support system will be replaced by a new turntable which provides increased load capacity and eliminates the need for a large fairing presently used in conjunction with a high angle of attack model support device. The test chamber lighting will be improved. The tunnel column supports will be modified to meet established seismic

design requirements. An existing 3,000 psi (207 x $10^7 n/m^2$) air supply system will be extended 700 feet (213 m) using 4-inch (10.2 cm) diameter underground pipe to furnish up to 20 pounds/second (9 kg/sec) of air to the models. This facility is presently utilized over 12 hours per day in support of NASA, DOD, government and industry research programs relating to highly maneuverable aircraft and missiles, advanced aircraft and other aerospace projects. New test requirements will involve the use of high pressure air system for testing the powered nacelles, blowing flaps, powered rotors, control jets, or exhaust gas simulation.

2. Rehabilitation and Modification of the Storm Sewer System 195,000

This project provides for the rehabilitation and modification of the existing storm system. This rehabilitation work includes the replacement of the existing open storm water ditches in the northern section of the center by the installation of 2,400 linear feet (732 m) of corrugated metal pipe and the installation of manholes, catch basins, and culverts as required. These existing open ditches have been a continuous problem with sloughing of the banks, filling with debris, and are too shallow with consequent flooding of adjacent areas. In addition, the open drainage ditches must be continuously maintained to prevent the collection of stagnant water and the resulting breeding areas for mosquitoes. This work is needed now to eliminate further erosion and to improve the existing conditions in the area.

3. Rehabilitation of Research Support Building, N-213 405,000

This project provides for the rehabilitation of 33,300 square feet (3,094 sq. m) of interior space in the 25-year old west wing of the Research Support Building, N-213. The work will include the demolition of the existing partitions and the rehabilitation of the area for office space, electronic instrument assembly and repair, an instrument machine shop and computer areas. These interior modifications will include the installation of new partitions, floor coverings, ceilings, lighting systems, and enclose a stairway. The heating, ventilation, and air conditioning equipment will be rehabilitated including the addition of approximately 45 tons of air conditioning equipment. The roof of the east wing penthouse has deteriorated such that it leaks and disrupts activities on the second floor. Approximately 2,300 sq. ft. (214 sq. m) of this roof will be rehabilitated. This rehabilitation work is required to prevent further deterioration of this facility. This modification work will provide for the accommodation of personnel now located in five different locations. This consolidation will improve personnel efficiency and will accommodate the changing responsibilities and requirements of the center.

4. Modification of Water Supply Systems 395,000

This project provides for the modification of the water supply system as necessary to deliver 12,000 gpm (45.4 klpm) at 75 psi (5.2 x $10^5 nlm^2$) for fire water demand at the aircraft hangers. The water supply system will be modified by the installation of a new 18-inch (46 cm) diameter water main of

1,400 linear feet (427 m) from 750,000 gallon (2,839 kl) low level storage tank at the 40 x 80-Foot Wind Tunnel to the Flight Support Facility, Building N-211. This work will include a pumping station with multiple electric driven water pumps to provide the necessary flow and pressure. In addition a new 10-inch (25.4 cm) diameter water supply line of approximately 500 linear feet (152 m) will be installed from Building N-211 to the Aircraft Servicing Facility, Building N-248. This project is required to provide an adequate quantity and pressure of water to meet the fire water demand of these aircraft hangers.

B. Flight Research Center 265,000

1. Rehabilitation of Paving and Roadways 145,000

This project provides for the general rehabilitation of the paving and roadways at the Flight Research Center in anticipation of the added traffic occasioned by additional research support personnel involved in the flight aeronautical test programs such as Space Shuttle. This work will include the associated rehabilitation of the existing inadequate storm drainage systems and related problems. Also involved in this project will be the general rehabilitation including regrading and paving around Maintenance Dock, Building No. 4826, paving near Radar Building No. 4830, and regrading and paving at several additional locations at the Center. These paved areas have deteriorated to a level where without rehabilitation, major replacement will soon be needed.

2. Rehabilitation of Utility Systems 120,000

This project provides for the rehabilitation of the underground utility systems at the Flight Research Center. This work will include the rehabilitation by replacement of 33 existing 20-inch (50.8 cm) diameter deteriorated fire water system valves. The valves were installed in 1952 and the seats are badly corroded and will not operate effectively. This work also includes the rehabilitation by replacement of approximately 3,000 linear feet (194 m) of 4 inch (10.2 cm) diameter natural gas pipe which serves Boiler House No. 1 and the Center. Cathodic protection of this piping installation will be provided. The existing natural gas pipeline is badly corroded and failure would cause a disruption of service to the Center. These two work elements represent the most pressing area of the utility system that now need rehabilitation.

C. Goddard Space Flight Center 1,345,000

1. Modification to Mission Operations Facilities in Buildings 3, 14 and 23 270,000

This project modifies 19,000 sq. ft. (1,766 sq. m) of existing space in three buildings, the Central Flight Control and Range Operations Facility (Building 3), Spacecraft Operations Facility (Building 14), and the Interpretation Laboratory (Building 23), for the following functions: the Image

Processing Facility, Operations Control Centers, Information Processing Facility and Mission Computing Operations Facility. The modifications for the Image Processing Facility are required to accommodate new equipment to supporting image processing requirements stemming from on-going and approved projects such as LANDSAT, Heat Capacity Mapping Mission (HCMM), Stratospheric Aerosol Gas Experiment (SAGE) and NIMBUS-G. The modifications to the Operations Control Centers are necessary to meet changing spacecraft activities for follow-on spacecraft models which require new equipment and different personnel space configurations. The Information Processing Facility modifications are required to meet the changing needs within the Data Processing Facility. The Mission Computing Operations Facility requirements are for operational support. The modifications to these three buildings include partition changes, heating, ventilation, air conditioning and power changes.

2. Rehabilitation of Power Distribution System 110,000

This project provides for the rehabilitation of the power distribution system at Goddard Space Flight Center's Network Test and Training Facility (NTTF). This work involves the extension of a two-way ductbank and second high voltage feeder cable from the NTTF, Building 25, to an outlying distribution point and the extension of a four-way ductbank and feeder cable from the distribution point to the Frequency Standard and Test Facility. Additionally, an extension of a redundant low voltage feeder cable from the two-way ductbank to the 40-ft. (12 m) antenna will also be a part of this project. At present, the Frequency Standard and Test facility is supplied electrical service through buried cable. This method imposes limitations on system reliability, ease of maintenance and growth. This cable has reached its design lifespan and deterioration has occurred. With the attendant increase in use, the risk of failure of this cable is high. The Frequency Standard Test Facility supports a GSFC program to develop advanced atomic hydrogen time standards. These standards will support such programs as the San Andreas Fault Experiment (SAFE), the Earth and Ocean Physics Applications Program (EOPAP) and the Space Shuttle Program. A second feeder cable and ductbank will provide a redundant power supply to ensure the reliability of the system. The 40-ft. (12 m) antenna at the NTTF is also supplied power via a cable trench. This facility has been assigned a prime role in support of the International Ultraviolet Explorer (IUE) Satellite Program, and a redundant feeder cable will assure a reliable power supply.

3. Modification of Fire Protection Systems in Various Buildings 490,000

This project consists of a number of modifications for Fire Protection and Safety. There are five parts of this project to be completed. They are: the upgrading of the computer facilities; rezoning for heat and smoke detection for office/laboratory buildings 3, 14, and 23, sprinkler systems for office/laboratory buildings 15, 18, 21, 23 and 26; extension of fire protection systems in buildings 308, 309, 310 and 311 at the Magnetic Test Facility; the smoke detection and sprinkler systems in buildings 201, 205, 206 and 208 at the Optical Research Facility. These modifications are those items that are most essential

and necessary for the safety of personnel and high value equipment. Prior year funding at Goddard for these general types of fire protection and safety items totaled $3,406,000. Future funding of this type work is now estimated at approximately $2,600,000 to be progressively accomplished on a priority basis over several years.

4. Modifications for an Applications Support Facility, Building 16 475,000

This project is a phase of an anticipated three/four phase effort to adjust space utilization at the Goddard Space Flight Center (GSFC) so that an area will result which can be dedicated to use as an Applications Support Area. This phase proposes the modification of approximately 6,000 sq. ft. (560 sq. m) of existing space in Building 16. Office, laboratory and special purpose spaces in the existing building will be modified to house the laboratory space to be utilized as discussed below. Modifications will be made to partitions, heating, ventilating and air conditioning systems, fire detection and protection systems and the power distribution system. Raised floor area will be provided for use as automatic data processing space and will house the first increment of the Application Information Processing System (AIPS) computing equipment. To provide this area in contiguous space and collocated with the Applications Directorate engineers and scientists, other existing activities will be relocated to other areas on-Center to be made available for this purpose by a series of related consolidations and space reallocations. The GSFC has continuing responsibility for the development and conduct of space flight experiments and investigations in the Applications area. The Application Program furthermore is designed to apply scientific data gathered through NASA satellite missions to users on both a scientific and layman level. To continue to meet this objective in the future, new laboratory capability is required for applications data processing and information transfer to users. This is true since information extraction is a bottleneck in deriving maximum benefits from satellite data. Additional laboratory capability for applications information processing is needed for the following Applications disciplines:

Weather and Climate Observation and Forecasting
Environmental Quality Monitoring
Ocean Condition Monitoring and Forecasting
Materials Processing in Space
Earth Resources Detection and Monitoring
Earth Dynamics Monitoring
Space Communications

This resultant area will provide computational capabilities which do not now exist at the GSFC. These include on-line, interactive image analysis; "real-time" image analysis; access to discipline oriented, on-line data bases; and the networking of computers with other NASA Centers and outside users for the exchange and sharing of mission data and information. These capabilities are essential for greater utilization by a larger number of users. It is estimated that the remaining phases will cost between $800,000

to $1,000,000 to be programmed over succeeding years. This work is being done within the context of an overall utilization plan which can only be implemented on a progressive basis.

D. Jet Propulsion Laboratory 1,670,000

1. Rehabilitation of Heating, Ventilating and Air Conditioning System in the Space Flight Operations Facility (SFOF), Building 230 400,000

This project provides for the rehabilitation of major elements of the heating, ventilating and air conditioning (HVAC) system of the Space Flight Operations Facility (SFOF), Building 230. Included is the replacement of five separate roof mounted cooling towers with two new units (900 tons ea.), replacement of two roof mounted air handlers, piping system revisions, replacement of worn out boilers (70 HP) and centrifugal chillers (250 tons). Related modifications to ducting, roofing, controls, electrical power and painting are also included. Building 230 is the nerve center for world-wide control and operations of the Deep Space Network (DSN). It contains several major computer systems, Teletype Writer Exchange (TWX), telephone, and radio links to all remote DSN tracking stations. Installed value of equipment is well over $30,000,000 and operation has resulted in failure of some HVAC equipment elements, others show signs of incipient failure. Frequent alteration and expansion of the computer complex to handle mission requirements places new loads on the HVAC system that cannot be reliably supported without system rehabilitation. HVAC system failures could result in all flight control and data handling computers shutting off due to over temperature. Maintenance costs are increasing, some equipment elements are now out of production, and the age of most equipment is approaching 15 years. It is felt that further delay in the HVAC system rehabilitation creates an excessive risk to all flight project data handling capabilities.

2. Rehabilitation of Heating, Ventilation and Air Conditioning System in the Facility Engineering Office, Building 200 140,000

This project provides for the rehabilitation of a 60-ton air conditioning system serving the first and second floors of the Facility Engineering Office Building. The work involves partition relocation, installation of piping and ductwork systems, new control systems, removal of worn out heat pumps, roof repairs around penetrations and lower floor arrangements. No major changes have been made to the 15-year old original heating, ventilating and air conditioning equipment in Building 200. System performance is inadequate, maintenance is excessive, and the system is under capacity for support of the newly assigned personnel and data system loads.

3. Modifications of Utility Control System 245,000

The Utility Control System (UCS) provides a means of remotely controlling, measuring values, and determining the status of temperatures, pressures, humidities, and electrical load consumption in various

mechanical rooms. This is Phase II of a III-Phase project. Phase II consists of multiplex equipment, building control panels and system control and monitoring points for the buildings with a total of 490 individual addressable points. This system when completed will give operation personnel the opportunity to monitor and optimize the control of all buildings on a continuous basis. This project is necessary because each building has its own heating, ventilating and air conditioning system. Consequently, roving patrols are necessary to monitor and repair approximately 150 buildings on the Laboratory. When equipment malfunctions, immediate notification minimizes unscheduled shutdowns thereby preventing potential damage to equipment requiring close environmental control. This phase of the total project will have a "payback" period of 2.3 to 2.5 years. Prior year funding was in the amount of about $400,000.

4. Modification of 16.5 KV Feeders from Substation G to Transformer Banks 63, 65, and 69 415,000

This project proposes to modify the old existing overhead 17 kv distribution system, covering the east portion of the laboratory, with a new underground dual radial distribution system. The work consists of adding switchgear at Substation G, utilizing existing and adding some underground conduit and pulling two feeders in conduits from Substation G to Surveyor Road, then north to Explorer Road and east to Mariner Road. Banks 63, 69 and a new bank in the General Offices Building, Building 111, are to be connected to the new feeders. The existing overhead distribution system was installed about 30 years ago and has been modified and relocated as JPL expanded. It is now a loop circuit with sectionalizing air switches that are not interlocked for safety. The proposed selective radial system will provide modern distribution in the area now served by the overhead system. The proposed system is similar to the underground selective radial system in the newer areas at JPL. This project will be the first phase of work on the overhead system. The remaining portion will cost approximately $400,000.

5. Modification to Space Flight Operations Building, Building 230, Central Transformer and Switchgear Installation 470,000

This project will modify the electrical system for the Space Flight Operations Facility (SFOF), Building 230 including the relocation and replacement of electrical transformers, motor controls, switches, and other electrical equipment items. This building was built in four increments with four separate electrical substations and systems. Two of the main transformers have failed a number of times and require replacement. Cross feed back-up circuits and uninterruptible power systems are required to prevent the loss of power to the critical computers used for spacecraft mission control and data handling and to ensure 100 percent reliability. The entire electrical system of this building has been reviewed to ensure that the planned modification will be matched to the programmatic requirements of the facility. This proposed work includes the relocation and/or replacement of equipment, replacement of portions of the distribution system and modification of the ground fault system to prevent arcing ground failures. This project is independent from the heating, ventilating and air conditioning work to be done also in Building 230.

E. Johnson Space Center 1,200,000

1. Modifications to Oxygen and Altitude Vacuum Systems Life Sciences Laboratory, Building 7 155,000

This project provides for modifications to the altitude chamber vacuum system and provides a stainless steel gaseous oxygen distribution system for the test facilities in the Life Sciences Laboratory, Building 7 at JSC. Upgrading of the gaseous oxygen distribution system consists of replacing existing copper tubing headers and branch lines with a more reliable and maintainable stainless steel system. The stainless steel oxygen system is required to eliminate particulate contamination from oxidation which occurs in the interior of the existing copper lines. Modification to the altitude chamber vacuum system consists of installing two existing liquid nitrogen cold traps to improve the vacuum capability by removing water vapor from the system.

2. Rehabilitation of Heating, Ventilating and Air Conditioning Systems in Various Buildings 350,000

This project provides for rehabilitation of deteriorated heating and cooling system equipment in 25 buildings at JSC. The work includes rehabilitating or replacing valves, pumps, fan and coil assemblies, air-handler casings and structures, and other associated equipment. This specific effort is part of a continuing program to rehabilitate the heating and cooling systems at JSC. The deterioration of the equipment has been accelerated by the high humidity and salt/chemical content of the air in this region. The energy consumption will be decreased because of the improved efficiency of the heating and air conditioning systems, and the frequency of breakdown and repair will diminish.

There have been several malfunctions of steam and chilled water valves. Also, various components of the heating and cooling systems have deteriorated to a point where collapse is imminent. If corrective action is not taken, the testing of mission essential equipment will be placed in jeopardy.

This is Phase IV of this work. Phases I, II and III were accomplished in FY 1974, 1975, and 1976 at an approximate cost of $750,000. Future work to complete this type of rehabilitation will cost $1,120,000 (FY 1977 dollars).

3. Rehabilitation of the Chilled Water and Steam System 120,000

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 one steam boiler, instrumentation, and auxiliary equipment; the replacement of condensate and steam valves and expansion joints; the rehabilitation of the chiller system,

instrumentation, and auxiliary equipment; the repair and/or replacement of chilled water valves; the rehabilitation of the cooling tower structure and systems; and the replacement of insulation and covering on the chilled water and steam piping systems.

This is part four of a five-year program of rehabilitation of the Central Heating and Cooling Plant and distribution systems. Phases I, II, and III were included in the FY 1974, 1975, and 1976 programs and cost $830,000. Phase V will cost approximately $400,000 (FY 1977 dollars). 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 of the tubes and firebox is necessary at this time to prevent further deterioration, which would necessitate complete boiler replacement. A failure of the heating and cooling system would impair the Center operation and impact the NASA program.

4. Rehabilitation of the Sanitary Sewer System 150,000

This project provides for the rehabilitation of approximately 2,800 linear feet (853 m) of the gravity sewer lines at JSC. The segments of the existing JSC sewer lines which require single point repairs and slip lining, are based upon a television inspection of the sewer system. The pipe sizes vary from 6 inches (15 cm) to 15 inches (38 cm) in diameter. Pipe segments which are broken will be replaced and manholes will be repaired as required. This work is required because of line settlement caused by the swelling and shrinkage characteristics of the soil and, to a certain extent, by land subsidence in the area. It is anticipated that nearly 16 percent of all lines will need either repair of slip lining to prevent the recurrence of blockages from either breaks or soil infiltration.

This is Phase II of a III-Phase project. The first phase was accomplished in prior years using R&PM funds at a cost of $160,000. Phase III will cost approximately $150,000 (FY 1977 dollars).

5. Modifications of Fire Detection Systems in Various Buildings 125,000

This project provides for various modifications to upgrade the fire and intrusion alarm systems in 52 JSC buildings. The upgraded system will include panels with lightning arresters, transmitters, central receiving equipment, and voice recording equipment for recording and verifying time, locations, and nature of emergencies from incoming calls. These modifications are required because the present equipment is obsolete, unreliable, and outdated to the extent that it does not provide adequate records. In addition, since most JSC facilities do not have fixed automatic fire suppression systems, reliability of detector and alarm systems is vital so backup power supplies are necessary.

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Prior year fire protection work was done at a cost of $900,000. Future funds for similar work will cost $150,000 per year for the next 5 years.

6. Rehabilitation of the Electrical Distribution System 185,000

This project provides for rehabilitation of the primary electrical power cables which serve the Thermochemical Test Area (TTA) and the utility tunnel. The work includes replacing the existing 15-kv underground cable from oil switch 300 to the switchgear in each of the buildings in the TTA, from the JSC main substation to buildings fed from the utility tunnel at a point near the Technical Services Shop, Building 10, and from the JSC main substation to Vibration and Acoustic Facility, Building 49. The replacement of these cables is needed to remove the potential of power failures and possible impact on tests or other activities at JSC.

7. Rehabilitation and Modification of Various Buildings and Structures, WSTF 115,000

This project provides for rehabilitation and modification of various buildings and structures at the White Sands Test Facility (WSTF), New Mexico. Seven buildings in the Project Control Area 100, and the Laboratory Area 200, representing approximately 66,400 sq. ft. (6,168 sq. m) of floor area will be refurbished and improved. Approximately 1,250 sq. yds. (1,045 sq. m) of concrete slab liner and 1,400 ft. (427 m) of propellant inert construction joints in the Propulsion Test Area 400, propellant disposal ponds will be repaired and recoated. Modification and rehabilitation will also include the sewage lagoon aeration system. Other modifications include installation of an air conditioning system of approximately 10-ton capacity for use in the Preparation Building 200, clean room and chemistry laboratory areas. This rehabilitation and modification work is necessary to reduce maintenance and to restore the buildings to a condition suitable for use in supporting future program and project requirements. Some of the work is required to eliminate unsafe conditions, to eliminate a potential pollution problem, and to minimize an odor producing condition. The installation of the 10-ton air conditioning system will conserve energy by allowing limited utilization of two 50-ton units when only the clean room and chemistry laboratory areas are in use.

F. Kennedy Space Center 1,190,000

1. Rehabilitation of the Vehicle Assembly Building Room, Building K6-848 265,000

This project provides for the removal of the present gravel, resaturation of felts and the application of new gravel to an area of approximately 160,200 sq. ft. (14,888 sq. m) of roof surface. The work includes resealing 325 lineal feet (99 m) of gravel stops and flashings, and refilling 18 pitch pans. The Vehicles Assembly Building (VAB) has been in use since 1966 and has recently developed many leaks which cannot be effectively patched. The age of the roof and the effects of "ponding" after heavy rains have

caused loosening of the gravel and cracking of the roof seal. Resaturation and gravel replacement are necessary to prevent accelerated deterioration of the roof and possible water damage to equipment and materials in the low bay.

2. Rehabilitation of the High Temperature Hot Water System, KSC Industrial Area 410,000

This project provides for the rehabilitation of deteriorated portions of the existing underground high temperature hot water distribution system with an above-ground system. Approximately 2,800 linear feet (853 m) will be replaced with new insulation and protective jackets. In addition, associated valves and sleeves will be rehabilitated. At present, surface run-off water enters the sleeves and soaks the insulation on the underground pipes causing deterioration and resulting in further corrosion of the pipes. This rehabilitation will eliminate the growing heat loss for the systems and result in some energy savings (fuel oil). This project currently consists of the most critical portions remaining of the program started in FY 1974 for the rehabilitation to the high temperature hot water system in the KSC Industrial Area. Approximately $1.1 million of rehabilitation effort will be required in future years to complete the program. Approximately $700,000 has already been spent to rehabilitate this system.

3. Rehabilitation of the Space Launch Complex 2W (SLC-2W) Mobile Service Tower, Western Test Range (WTR) 190,000

This project provides for the rehabilitation of the Space Launch Complex 2W Mobile Service Tower at the Western Test Range (WTR). This work includes sandblasting and providing corrosion protection to the tower framing and decking, and replacing those structural members that have corroded beyond repair. This project is necessary to maintain the facility in operational condition and prevent accelerated corrosion resulting from exposure to salt air.

4. Rehabilitation of Launch Complexes 36A and B 325,000

This project provides for general rehabilitation of LC-36: (1) the LC-36A Mobile Service Tower (MST) bridge crane will be replaced to ensure reliability and safety during lifting operations. The hoist is exposed to a high moisure and salt content atmosphere and has deteriorated over the years to where major rehabilitation is necessary; (2) the flat roof on LC-36B will be replaced with a sloping built-up roof to assure good drainage. The present roof is approximately 12 years old. Due to deterioration and rain water pooling, spot patching has not been effective; (3) the rails and associated hold down hardware, on which the LC-36B MST is moved away from the launch vehicle during launch operations, will be removed, cleaned, regrouted, and shimmed to re-level the tracks. This work is necessary because the rails and track bed have settled over the years from frequent use; (4) the flammable fiberglass wall panels and thermal insulation on the upper levels of the LC-36B MST will be replaced with fiberglass panels and insulation meeting

a flame spread of 25. The existing panels present a potential fire hazard to personnel and flight hardware. Fiberglass is used to provide a radio frequency transparent enclosure required for checkout of radiating flight hardware; and (5) the grounding system for the LC-36B propellant servicing lines will be modified to assure personnel safety during propellant flow.

G. Langley Research Center 1,840,000

1. Rehabilitation of the Low Frequency Antenna Test Chamber, Building 1299 375,000

This project provides for the rehabilitation of the Low Frequency Antenna Test Chamber in Building 1299. This work will include the removal and replacement of 17,000 square feet (1,580 sq. m) of deteriorated anechoic foam absorbent material with a new improved material which has been treated to improve its fire resistance. In addition, since the new foam absorbent material is less fire susceptible, an existing potentially hazardous condition now requiring special security measures is eliminated. This improved material will also permit throat reshaping to modify chamber response and improve performance. Rehabilitation of the chamber is required for antenna pattern, impedance, and scattering measurements in support of the Aerostat Antenna Development. This improved facility will also be used for the calibration and measurement of radiometer antenna for the Advanced Applications Flight Experiments, Earth Energy Satellites, and Microwave Landing System test.

2. Rehabilitation of Electrical Power Distribution System - 110KV 405,000

This project provides for Phase IV of a planned rehabilitation of the electrical power system at the Langley Research Center. This work includes the rehabilitation of the 110-kv electrical power system at the Stratton Road Substation. Two existing circuit breakers will be replaced with new 1,600-ampere, 100-kv oil circuit breakers capable of safely interrupting service. The incoming 110-kv service line No. 2 bus will be extended. Sectionalizing switches will also be installed to enable substation components to be isolated for reduced cost in maintenance or repair without having loss of electrical service to the entire Center and the Air Force Base. This work will also include the rehabilitation by replacement of defective ancillary items such as insulators, structural steel, and equipment pads. Further upgrading of the substation includes the provision of a fire protection system to avoid a catastrophic failure. This system will limit the extent of damage due to fire in case of a transformer rupture which may occur under an unusual fault condition. This rehabilitation of the Center's electrical power system will improve the system's safety from short-circuit interruptions and is also needed to limit the extent of damage under failure conditions.

3. Rehabilitation of West Area Sanitary Sewer System 240,000

This project provides for the rehabilitation of the West Area Sanitary Sewer System. The existing 10 inch (24.4 cm) diameter sanitary sewer line will be replaced with 1,460 feet (445 m) of 18-inch (46 cm) diameter cast iron line along Ames Road from Freeman Road to Taylor Road. A 24-inch (61 cm) diameter cast iron line of 1,380 feet (421 m) will be installed from the intersection of Ames and Taylor Roads to Lift Station No. 4. The existing 10-inch (25.4 cm) diameter line was installed in 1952 to service the Unitary Plan Wind Tunnel, Building 1251, and is deteriorated and undersized. In addition, Buildings 1202, 1250, 1262, 1286, 1293, 1299, the Chemical Magazine Test Area, and the Hypersonic Physics Test area have been connected to the West Area Sanitary System. This presently overloaded system will be further aggrevated by the new System Engineering Building which will be completed in early 1976. Portions of the 10-inch (25.4 cm) diameter sewer line have been exposed in connection with other construction and it was noted that the joints leaked and the clay pipe is soft. Failure of this inadequate sewer system could cause a shutdown in an area which services over 1,100 employees.

4. Rehabilitation of Hangar Annex, Building 1244D 300,000

The project will provide for the rehabilitation to improve the reconstructed Hangar Annex, Building 1244D for additional storage and work areas. This project will include the installation of additional power and lightning, partitions, reinforcement of the structural frame, and roof and siding insulation. New heating, air conditioning, and a 14-foot (4.3 m) wide roll-up door is included with the project. The work will provide the space for and the installation of the rotor systems research aircraft calibration fixture and its support apparatus. This rehabilitation work will also provide a shop area of 2,400 sq. ft. (230 sq. m) and a clean room of 2,250 sq. ft. (209 sq. m) for rotor balance functions. The existing hangar addition is a pre-engineered structure which is over 16 years old, and has been moved and re-erected twice. The rehabilitation work is required at this time to provide more advantageous use of the available space in support of Aeronautics Research Programs.

5. Modification of Auxiliary 150-psi Air Supply Aircraft Noise Reduction Laboratory Building 1208 195,000

This project provides for the modification to the auxiliary air supply line in the Aircraft Noise Reduction Laboratory (ANRL), Building 1208. the existing 15-psi ($1,034 \times 10^5$ n/m^2) air supply line to the anechoic chamber plemun will be upgrated to 150 psi (1.034×10^6 n/m^2) to provide quiet high pressure air to models and noise sources. A new larger quiet flow control valve will be ipstalled parallel with the existing one to provide higher mass flows. The auxiliary 150 psi (1.034×10^6 n/m^2) will be extended to the existing 4-foot (1.2 m) duct to provide quiet air for research models and noise sources. Upgrading the system includes replacement of the existing flexible pipe with a 10-inch (25.4 cm) rigid steel pipe. Increasing the mass flow rate and pressure, and extending the air supply to other locations are required

to support high priority forward motion effects research relating to the control of forward and rearward radiated noise from inlets and exhaust jets of current and future conventional takeoff and landing, and supersonic aircraft. The auxiliary air system is also needed to operate model jet exhaust systems, suppression devices and controlled noise sources in conjunction with the existing ANRL primary air and flow duct systems.

6. Modification to 350-psi Air Supply East Area 325,000

This project will provide for the modification of the process air for all Langley Research Center facilities in the East Area by the installation of a 350 psi (2.413×10^6 n/m^2) compressed air distribution system. This work will include the installation of a new underground 8-inch (20.3 cm) diameter compressed air line approximately 2,000 feet (610 m) long from the Engineering Technology Laboratory, Building No. 646, to the Low Turbulence Pressure Tunnel, Building No. 582A. An additional 400 feet (122 m) of 3-inch (7.6 cm) diameter pipe will be connected into the 8-inch (20.3 cm) diameter main to supply the Transonic Dynamics Tunnel, Building No. 648, and the 8-foot (2.4 m) Transonic Pressures Tunnel, Building No. 640. New isolation and pressure reducing valves will be installed at each facility termination. The installation of these new compressed air lines will replace nine existing independent compressor systems of varying sizes located at these facilities. The new air supply will increase the maximum pumping rate by 3.5 times as compared to the rate for the two existing compressors. The new air supply will favorably impact operation of the Advanced Technology Airfoil Program which is supporting air transport and business jet aircraft with super critical airfoil designs and data.

H. Lewis Research Center 1,275,000

1. Modification of Flight Research Building, Building No. 4, for Fire Protection 465,000

The proposed project provides for the modification of the existing fire protection system in the Flight Research Building, Building No. 4, aircraft storage and service area. This modification will provide protection for an area of about 44,000 sq. ft. (4,088 sq. m) and will include an aqueous-film-forming-foam (AFFF) system, improved floor drainage system, and the installation of heat and smoke vents. The AFFF system will consist of eight horizontal discharge nozzles capable of spraying 3,400 gallons (12.8 kl) per minute. The concentrated foaming agent will be stored in a 2,000-gallon (7.6 kl) storage tank. The water will be provided by the domestic water supply through two 3,300-gallon (12.5 kl) per minute booster pumps. A separate drainage system with additional floor drains and pipes will discharge into holding tanks of 70,000 gallon (265 kl) capacity to prevent foam water and spilled fuel from reaching the domestic storm drainage system. Modifications will also be made to buildings, ventilation and electrical power systems. The automatic fire protection system is for personal safety and to protect the building, aircraft, and research equipment valued at approximately $23,500,000. Loss of aircraft and related research equipment would impact the Quiet Engine Development Program, and the Turbo-Jet Engine Flight Test Research Program.

2. Rehabilitation and Modification of East Wing of Engine Research Building, Building No. 5 355,000

The project provides for the rehabilitation and modification of 9,039 sq. ft. (840 sq. m) of research test facilities in the East Wing of the Engine Research Building (ERB), Building No. 5. The exterior work will include the rehabilitation of the exterior masonry walls, replacement of the roofing, waterproofing of parapets, removing obsolete support equipment on the roof, and replacing exterior doors. The building interior will be rehabilitated by installing new floor covering. Modifying the electrical power, lighting, heating, ventilating, and air conditioning systems, will be provided with this project. Acoustical ceilings will be installed in the hallways to reduce the noise levels. The East Wing of the ERB was constructed in 1943 and has been without major modification or repairs. This extensive rehabilitation and modification of both the interior and exterior of the building is required to restore the facility for future research programs. This wing contains 12 test cells and 6 control rooms and rehabilitation is needed for energy oriented automobile and aircraft engine test programs.

3. Rehabilitation and Modification of Central Portion of Utilities Building, Building No. 15 455,000

This project provides for the rehabilitation and modification of the central portion of Utilities Building, Building No. 15. This rehabilitation includes the replacement of the wood windows in the entire building with double glazed aluminum windows. The present wood windows have deteriorated and require constant maintenance. The double glazed aluminum windows will reduce maintenance cost, conserve energy, and shield out exterior noises. This project also provides for the rehabilitation and modification of 14,250 sq. ft. (1,300 sq. m) of the building. The exterior work will include tuck pointing and waterproofing of the masonry walls, repairing the roof, and replacing the exterior doors. The existing wood stairway will be replaced with front and rear stair towers and entrances. The interior work will include replacing the walls, acoustic ceilings, floor covering, plumbing, heating and air conditioning systems. The lighting, communication, fire protection, and power systems will also be improved. The building was constructed over 32 years ago and in the insuing time has evolved from a central firehouse to its present multipurpose role. In addition to the original equipment and systems being worn and requiring replacement, these changes in the function require extensive rehabilitation of the space and improvement of the interior and exterior to provide for adequate facilities to support research activities.

I. Marshall Space Flight Center 1,515,000

1. Modifications for Industrial Waste Treatment Facility, Building 4739 410,000

This project will provide the means for control of pH levels and will remove toxic components from the various industrial aqueous wastes discharged from various facilities at Marshall Space Flight Center (MSFC). The system will consist of the installation in the Industrial Waste Treatment Facility, Building 4739, of package systems for destruction of cyanides in cyanide-bearing rinse waters, removal of chromium

in chromium-bearing waste waters, neutralization of final pH adjustment and precipitation of all other heavy metal hydroxides, clarification, separation and removal of precipitated hydroxides. Various holdtanks, feedtanks, pumps, and instrumentation and controls will also be provided. The system will be designed to permit future addition of a reverse osmosis or ion exchange apparatus in order to comply with the 1983 and 1985 effluent regulations. When the current industrial waste system was put into operation in 1970, the Environmental Protection Agency's (EPA) effluent regulations were less stringent than at present. This facility is required to comply with the EPA 1977 effluent regulations.

2. Modification of Utility Control System 240,000

The Utility Control System (UCS) provides a means of remotely measuring values and determining status of temperatures, pressures, humidities, and electrical load consumption in various mechanical equipment rooms and critical installations throughout MSFC. Control functions are also included for starting and stopping entire air conditioning systems from a central remote site. The existing UCS in Buildings 4663, 4487, and 4708 will be updated and the systems expanded to include monitoring and control of functioning equipment in mechanical equipment rooms in eight MSFC office buildings, shops, and laboratories as follows: Buildings 4353, 4471, 4481, 4485, 4610, 4612, 4613, and 4619. The UCS provides a central point for control of air conditioning equipment. Through implementation of this project utilities savings will be $100,000/year, which amortizes the investment in 2-1/2 years. This estimate does not include the savings to be realized in maintenance surveillance manpower. Trend analysis will prevent costly shutdown of computer equipment by "anticipating" malfunction of mechanical equipment. The existing UCS has been in operation for eight years and has proven reliable and beneficial in trouble shooting and maintenance of air conditioning equipment in the three larger MSFC buildings being served. When equipment malfunctions, immediate notification minimizes unscheduled shutdowns thereby preventing potential damage to critical computer and electronic test equipment requiring close environmental control.

3. Rehabilitation of Office and Engineering Building, Building 4610 West 355,000

This project will provide for the rehabilitation of the west portion of the Office and Engineering Building, Building 4610, which has a floor area of approximately 62,000 sq. ft. (5,762 sq. m). The work consists of rehabilitation of the lighting and power distribution systems and the rehabilitation of the heating, ventilating and air conditioning system. This part of the building was constructed in the late 1950's utilizing very minimal standards. Continued utilization of this facility is imperative in support of the Center's missions in research and engineering work for assigned programs and activities. Accordingly, it is necessary to upgrade the building interior and utility systems to prolong its usefulness. The building systems are obsolete, inefficient, and require excessive maintenance and repair. This project will result in the reduction of both energy consumption and maintenance time.

4. Rehabilitation of Air Conditioning Systems, Missile Assembly and Inspection Hangar, Building 4708, Phase II 355,000

This project provides for rehabilitation of obsolete air conditioning systems serving approximately 60,000 sq. ft. (5,576 m^2) of building area. The work will include installation of an existing 673-ton chiller and associated piping and controls in an existing equipment building. Approximately 15 individual direct expansion type systems will be replaced utilizing the new chilled water system. In addition, deteriorated or inadequate systems or components will be upgraded or replaced as required in order for this area of the building to meet user environmental requirements. The building houses or will house numerous activities critical to the support of the Center's technical and scientific programs, including Space Shuttle, HEAO, X-Ray Telescope, and Spacelab, plus various other MSFC-assigned programs. Ongoing program activities in the building are beginning, presently, to take an intolerable overload on the existing air conditioning systems serving this area. These systems are old, substandard, fragmented and have become unreliable. This is the second phase of a three-phase plan to upgrade the entire building's air conditioning systems. Phase I provides for the rehabilitation of an initial 40,000 sq. ft. (3,717 m^2) of this building as part of the FY 1976 CoF program at an estimated $350,000 cost. The future Phase III increment in this rehabilitation task will complete this work and is estimated to cost an additional $350,000.

It is urgent that a more efficient central system to replace the numerous small systems be provided for greater reliability, better environmental control and reduced operating and maintenance costs. Systems to be modified or rehabilitated will incorporate provisions for energy conservation.

5. Rehabilitation of Guidance and Control Building, Building 4487, Phase II 155,000

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 rehabilitated. 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. Phase I, included in the FY 1976 budget at $460,000, provides for the rehabilitation of the East end of the "A" Wing. A subsequent increment is estimated to cost approximately $500,000.

J. Michoud Assembly Facility 525,000

1. Rehabilitation of Manufacturing Building, Building 103 270,000

This project provides for rehabilitation of ten rooftop substations and electrical systems in Manufacturing Building, Building 103, and the replacement of approximately 1,950 feet (594.4 m) of 6-inch (15.2 cm) horizontal roof drain lines and risers which have developed leaks. Rehabilitation of the substations and electrical systems includes repairing substation doors, replacing open cable feeders from the substations to the circuit panels and replacing electrical safety devices to include overload protection of equipment. This project is necessary to improve safety conditions and operations of the electrical system in the building. This project will also prevent leakage from the horizontal drains and risers which could result in damage to the equipment and external tank components located below these drains and risers.

2. Modifications of Utility Control System (UCS), Phase II 255,000

This project provides for expanding the existing Utility Control System to monitor electrical loads at the 2 master and 18 distribution substations at the Michoud Assembly Facility. Automated start/stop control functions and monitoring sensors will be added to optimize power loads by allowing decentralized control of all principal electrical equipment used to support plant operations. Monitoring the status of circuit breakers and electrical loads at these substations will allow real-time recording and evaluation of power used throughout the manufacturing areas for temperature, humidity, pressure, light, and power so that heavy loads can be automatically rescheduled during nonpeak hours. This rescheduling will in turn reduce electrical demand costs, aid in conservation of electricity, and allow personnel to react faster to power outages. With proper monitoring and control, costs for electricity could be reduced by at least 10 percent. When manufacturing external tanks begins, yearly electrical bills are estimated to be about $2,650,000; the proposed modifications will allow savings of approximately $265,000 per year. Thus, the cost of this project would be amortized in less than one year. Phase I of this project was funded in FY 1976 at $315,000. This second phase will complete all known control and monitoring requirements at this time.

K. National Space Technology Laboratories 905,000

1. Rehabilitation of Roofs at 20 Buildings 255,000

This project provides for the rehabilitation of approximately 482,000 square feet (44,780 square meters) of roof area on 20 buildings at this location. This rehabilitation work will include the replacement of selected sections of the deteriorated roofs, and the reworking of expansion and contraction cracks and adjoining openings through the roofs at parapets. The work also includes the installation of roof vents to dry out trapped moisture. Despite patches and repairs, the roofs on some buildings have numerous leaks, soft spots where the insulation has been saturated, and blisters from trapped moisture. These roofs

are over ten years old and detailed radioisotopic inspection surveys during the past year have indicated the need for this rehabilitation work. Delay of the rehabilitation of these roofs will result in further deterioration of the roof surfaces, underlayments, insulation, and decking to a point which would require major reworking of the roofs of many of the buildings.

2. Rehabilitation of Roads in Buffer Zone 240,000

This project provides for the rehabilitation of approximately 4.4 miles (7.1 KM) of 24-foot (7.3 m) pavement of the south access road into the Center. The work will include removal and replacement of sections of pavement and or base materials, in-place rehabilitation of existing flexible payment, laying a leveling coat, binder coat, and wearing surface, buildup of the shoulders, and restriping of finished pavements. With the acquisition of the NSTL, a portion of the Mississippi Road System, now State Road 607, was absorbed into the Fee area and closed to the public, thereby becoming the responsibility of NASA for rehabilitation. During the construction in the area this road received far more traffic than anticipated. This increased traffic and wheel loading, coupled with long heavy wet seasons has caused this access road to deteriorate. Conditions of the road are such that unless the proposed rehabilitation is accomplished it could become necessary to do major replacement of the roadway.

3. Modification of Sewage Waste Treatment System 410,000

This project provides for the modification of the existing sewage waste treatment systems at NSTL to meet present water control regulations established by the Environmental Protection Agency (EPA). The existing three sewage lagoons will be replaced with two extended aeration package treatment plants. The first waste treatment plant will be located in the vicinity of the existing Sewage Lagoon No. 1 and will provide treatment for the Engineering/Administration, and Maintenance (Industrial) areas. This new system will consist of approximately 5,770 feet (1759 m) of 4-inch (10.2 cm), 6-inch (15.2 cm), and 8-inch (20.3 cm) diameter cast iron force mains. A new lift station will be provided in the vicinity of Sewage Lagoon No. 2 and connected by a force main to Manhole II. Sewage Lagoon No. 2 will be maintained as an experimental lagoon for performing research on the use of vascular aquatic plants in the treatment of raw sewage. The modifications to the existing waste water treatment system are required so that the effluent will meet secondary treatment standards as set forth by the EPA and the State of Mississippi Air and Water Pollution Control Commission. Presently, they are operating under a national pollutant discharge elimination system permit from EPA which expires July 1, 1977. By combining the waste water systems, and the installation of the packaged treatment plants, not only will the effluent meet regulations, it will also reduce operations and maintenance costs.

L. Wallops Flight Center 1,315,000

1. Rehabilitation of Airfield Facilities 410,000

This project provides for a 2,000-ft. (610 m) drainage system parallel to runway 10/28, pavement improvements to the south end of runway 4/22, repair of joints and spalling areas on aircraft ramps at hangar area D-1 and N-159, including the repair of drainage catch basin. The drainage system of runway 10/28 will allow entrapped surface water to drain from the runway. Pavement improvements to the south end of runway 4/22 will make this portion compatible with the test section of this runway. All concrete joints on aircraft ramps are in need of repair and this work will also improve the drainage of this area.

2. Rehabilitation of the High Bay Assembly Shop, Building Z-41 390,000

This project provides for rehabilitation and/or replacement of 6,440 sq. ft. (598 sq. m) of the concrete floor, rehabilitation of damaged partitions in the office area, replacement of damaged electrical conduit and cable ducts and replacement of the cooling tower for the High Bay Assembly Shop, Building Z-41. The floor in the facility has settled due to unstable subgrade and has become uneven over large areas. This rehabilitation is required to prevent further damage to utilities and to correct safety and reliability problems in the assembly of launch vehicles on an uneven floor. The cooling tower needs replacement due to deterioration with age and use in the saline atmosphere.

3. Rehabilitation of Various Buildings 160,000

This project provides for the rehabilitation of two buildings as follows:

a. Rehabilitation of Radar Building, Building U-25. This project provides for exterior waterproofing, roof rehabilitation, replacement of ceiling and floor tile in the shop area, rehabilitation of the heating system and replacement of the hot water boiler. This work is required to prevent further deterioration and to maintain the environmental standards required for the precise instrumentation housed in this facility.

b. Rehabilitation of Conference and Morale Activities Building, Building F-3. This project provides for rehabilitation of the roof, painting of the exterior, rehabilitation of the conference and toilet facilities, installation of new lighting and the relocation of the heating, ventilation and air conditioning cooling equipment to the roof. This work is required to prevent further deterioration of this 30-year old building.

4. Rehabilitation of the Aircraft Maintenance Hangar, Building D-1 355,000

This project provides for rehabilitation of the exterior of this hangar through the replacement of 25,700 sq. ft. (2,388 sq. m) of built-up roofing, replacement of windows on the south wing and upper bay, and for the installation of a central air conditioning system to serve the second floor of the south wing. This project will complete the exterior rehabilitation of the building and prevent further damage to the interior from window and roof leakage. The new air conditioning system will provide more efficient operation than the existing 19 window units. Prior funding (FY 1971 and FY 1976) for Building D-1 was $665,000 and it is anticipated that future funding of $455,000 will be required to complete work on this facility.

M. Various Locations 1,820,000

1. Rehabilitation of Air Conditioning System at Fairbanks, Alaska 120,000

This project will rehabilitate existing air conditioning systems in the Operations Building at the Fairbanks Station. Since the installation of the original equipment, new electronic systems have been added without any corresponding increase in the cooling system. In addition, most new electronic systems introduced as replacements of old systems have greater heat loads. This project will replace worn out equipment such as condensers, fans, and motors. Ducting and controls will also be modified or replaced and zones will be rerouted to accomplish optimum heat balance to protect electronic equipment from over heating and to establish a controlled environment for stable electronic operation.

2. Rehabilitation of Operations Control and Communications Building at the Goldstone Complex (MARS/DSS-14 and ECHO/DSS-12) 295,000

This project provides for rehabilitation of buildings and existing collateral equipment at the Goldstone complex. The work includes rehabilitation of roofs, walls and ceilings, the installation of air locks, replacement of incandescent lighting with fluorescent, modernization of the heating, ventilating and air conditioning system with economizer cycles and improved distribution and balancing and installation of modern and efficient utility controls. This work is required to improve the reliability of operations while providing savings in operations, maintenance and utility costs.

3. Modification of the Power Distribution Systems (DSN) - Various Locations 360,000

This project provides for the modification of the site power distribution at Goldstone (DSS-11) and Canberra (DSS-44) Stations. The work includes replacement of the 480-volt distribution switchgear, increasing installed transformer capacity for the Operations and Power Plant buildings, increasing the underground duct bank capacity, rehabilitation of the ground fault protection system and the modification

of the power distribution switchgear at each site. Implementation of the above work will minimize short circuit problems, minimize the safety hazard to operational personnel and reduce the station down-time caused by failures of the power distribution system.

4. Modification of Internal Lighting Systems at Various Locations (STDN) 290,000

This modification will replace incandescent fixtures in the Operations Building, STDN Stations, with Electro-Magnetic Interference (EMI) free flourescent fixtures. Fixture replacements will be made at the Goldstone and Canberra Stations. Electrical wiring and the ceilings will be modified to accept the recessed flourescent fixtures.

Until recently, incandescent fixtures were stipulated for use at the Space Flight Tracking and Data Network (STDN) stations because ballast used with the flourescent fixtures created an EMI in tracking equipment. Improvement in ballast has reduced this EMI disturbance and recent additions at the stations using flourescent fixtures have caused no noticeable increase in equipment disturbance. Incandescent fixtures use between 2-3 times the energy required for flourescent fixtures for the same candle power intensity. Air conditioning requirements would also be reduced due to less heat dissipation from flourescent fixtures resulting in additional energy savings.

5. Modification of the Power Plant at Ascension Island 120,000

This modification will replace deteriorated diesel engine radiators, install air shut-offs on diesel engines to prevent damage or destruction to the engine and alternator in event of an engine runaway. Also included is the relocation of diesel engine control panels from engine mount to floor mount to reduce vibration and the possibility of an undesirable engine shut-down or failure; the installation of frequency and voltage monitoring cubicles and kilowatt recording meters to retain operational history that can be utilized in the evaluation of equipment operation; and replacement of two transformers which are presently overloaded because of increased station loads.

6. Modification of the Utility Control Systems at the Goldstone Complex 435,000

This is the first of a two-phase project to provide a utility control system for the Goldstone Complex. This system will be composed of a real time micro-processor subsystem for local monitoring and control at each of the five tracking facilities with a centralized mini-computer control system for the complex. This system will monitor and control commercial power, engine generator plants, heating, ventilating and air conditioning systems, fire protection systems, power and water distribution systems. This system will accept weather and tracking schedules to permit predictive response. Should there be a failure in the Utility Control System the equipment returns to a manual mode or to its normal operating mode. The first phase will be completed at the following stations: DSS-12 (Echo) and DSS-14 (Mars).

7. Rehabilitation of Three Buildings at the Scout Launch Facilities, East and West Sites 200,000

This project provides for the rehabilitation of three buildings at the Scout Launch Facilities. Included in this work is the replacement of the heating system, rehabilitation of the roof and modification for the pressure vessel test cell in the Ordnance Assembly Building, Building 960 (Western Site). The work in the Operations Support Building, Building 582 (Western Site), includes replacement of the heating system, shelter cover for the nitrogen servicing system and paving. This project also includes roof rehabilitation, cooling tower and boiler replacement in the Assembly Shop, Building 3 (Eastern Site). The heating systems as well as roofs, tower and boilers in these buildings are more than 15 years old and need replacement or rehabilitation. The pressure vessel and shelter cover modifications are necessary for personnel safety, while the paving will provide for fire protection access to the launch pad area.

MISCELLANEOUS PROJECT LESS THAN $100,000 EACH 1,600,000

TOTAL..... 17,875,000

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 1977 ESTIMATES

MINOR CONSTRUCTION

Summary of Project Amounts by Location:	Amount	Page No.
Ames Research Center	560,000	CF 11-2
Flight Research Center	170,000	CF 11-3
Goddard Space Flight Center	235,000	CF 11-4
Jet Propulsion Laboratory	570,000	CF 11-4
Johnson Space Center	185,000	CF 11-5
Langley Research Center	865,000	CF 11-6
Lewis Research Center	250,000	CF 11-7
Wallops Flight Center	420,000	CF 11-8
Various Locations	1,245,000	CF 11-8
Miscellaneous Projects Less than $50,000 Each	625,000	CF 11-10
Total	5,125,000	

PROJECT TITLE: Minor Construction of New Facilities and Additions to Existing Facilities Not in Excess of $250,000 Per Project		
LOCATION: Various Locations		
	FY 1977 CoF ESTIMATE: $5,125,000	
FY 1975: $4,500,000	FY 1976: $5,000,000	TQ: $1,250,000

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 not to exceed $250,000. Such minor construction is necessary in FY 1977 to improve the usefulness of NASA's physical plant by making it possible to accomplish needed adjustments in the utilization and augmentation of its capabilities. Several projects are included in this year's minor construction program which relate directly to the conservation of energy.

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 1977 to meet general NASA installation requirements or technical facilities 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 1977 to meet the particular needs of one or more specific research or development programs and which could be adequately identified at the time of submission of this budget estimate. Items of work proposed to be accomplished within this program for

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FY 1977 have been carefully selected from a list totaling about $10.5 million. This selection has been made on the basis of the relative urgency of each item and the expected return for its accomplishment in relation to the investment involved. It is recognized, however, that during the course of the year some rearrangement of priorities may be necessary and that changes may be required in some of the items to be accomplished within the resources allocated.

PROJECT DESCRIPTION:

Tentative subprojects of work to be considered for accomplishment under this estimate are outlined under "PROJECT COST ESTIMATE" and total $5,125,000. Of the $5,125,000 total, $4,500,000 represents specific discrete items of work and approximately $625,000 is indicated 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 such project. This amount in turn is based on a listing of specific project tasks of the new construction type which must be accomplished in this time frame.

PROJECT COST ESTIMATE:

A. Ames Research Center 560,000

1. Construction of Addition to Utilities Along Moffett Boulevard 135,000

This project provides for an addition to the utility system along Moffett Boulevard. This work will include the installation of approximately 1,400 feet (427 m) of 6-inch (15.2 cm) diameter natural gas pipe line from Arnold Avenue to the northern portion of the Center. As a part of this work, Moffett Boulevard will be extended approximately 700 feet (213 m). New electrical ducts will be installed from manhole 133, approximately 1,300 feet (396 m), to the northern portion of the Center. This addition to the electrical system along Moffett Boulevard is required to provide a loop for the utility system and will contribute to the reliability of the electrical power to a segment of the Center. This extension of the utilities is in accordance with the master plan and will permit the location of planned improvements.

2. Construction of a New Test Leg in Fluid Dynamics Laboratory, Building N-231 245,000

This project provides for the construction of a new test leg parallel to the existing leg in the Fluid Dynamics Laboratory, Building N-231. This work will include a new settling chamber and a 4-foot (1.2 m) diameter by 20-foot (6.1 m) long pressure vessel to enclose future test sections of various geometric shapes. The test chamber will include a provision for the installation of a large porous walled test section with related piping and valving for the control of side-wall boundary layers. An addition of approximately 650 sq. ft. (60.3 sq. m) is included for the tunnel control room and data recording system. The pacing item for the development of advanced computer codes for ILLIAC IV, used in the design

of advanced high performance aircraft, is the turbulence models which account for significant viscous effects such as shock-induced separation. Such models will have to be developed and verified experimentally to take full advantage of the ILLIAC IV capabilities, since a larger computer would be required if turbulence was to be simulated by computation. The first computer codes requiring these turbulence models are ready for solution, and additional codes for predicting the lifting characteristics of airfoils will be ready for solution in FY 1977. Currently the chamber is limited to wing experiments for zero lift. This modification will allow experiments for modeling and verification for the case of lift over a practical range of Reynolds number by providing an increase in Reynolds number. An increase in test section size is necessary because of problems associated with the laminar sublayer and surface roughness effects at high Reynolds numbers.

3. Construction of Addition to Communication Ducts 180,000

This project provides for an addition to the communication ducts and manholes for communications, fire alarm, security, and other low voltage cables from the Administration Building, N-200, northward along Moffett Boulevard. Approximately 3,700 feet (1,128 m) of 6-duct bank with manholes will be installed from Building N-200 along Moffett Boulevard to Arnold Avenue. Approximately 2,400 feet (732 m) of 4-duct bank with manholes will be installed along Arnold Avenue from the corner of Moffett Boulevard and Arnold Avenue northward to the Static Test Stand, Building N-249, and south and east to the Unitary Plan Wind Tunnel, Building N-227. This work will include increasing the size of the communications distribution point in Building N-227. This installation of communications ducts is in accordance with the Master Plan and will be independent of the main electrical distribution system. This will permit the telephone company to install and maintain their cables in the proposed duct system. These ducts will provide for the existing facilities in the northern portion of the Center as well as making provision for planned future developments.

B. Flight Research Center 170,000

Construction of Addition to Radar Tracking Station, Ely, Nevada 170,000

This project provides for the construction of an 1,800-sq. ft. (167 sq. m) one-story masonry block addition to the radar tracking station on a mountain top near Ely, Nevada. This work will also include lighting and heat. Fire protection will be provided in the storage areas. This addition will provide space for the storage and shop repair functions now located in trailers adjacent to the radar tracking facility. The existing trailers are inadequate and unsafe due to the high winds, over 100 mph (161 km/hour), which are experienced frequently at this mountain top location. The wind has frequently damaged the metal roof material and sheeting of the trailers resulting in excessive maintenance costs.

C. Goddard Space Flight Center 235,000

1. Additions to Telescope Facility (Building 208) at the Goddard Optical Research Facility 120,000

This project provides for the construction of two 600-sq. ft. (56 sq. m) additions to the 48-inch (122 cm) Telescope Facility at the Goddard Optical Research Facility (GORF). These additions will be single story, prefabricated buildings with a connecting passage from the building addition to the radome telescope facility. The buildings will include a double door, heating, ventilation and air conditioning and power. One of the structures will be located north of the existing radome and the other will be on the west side.

The north building is needed to house advanced laser ranging systems for field evaluation and testing with the 48-inch (122 cm) telescope. The new building will support R&D experiments in laser ranging development for Earth and Ocean Physics Application Program (EOPAP), Sea Satellite (SEASAT) and Laser Geodynamic Satellite (LAGEOS).

The west building addition will house equipment for field evaluation and testing of advanced Optical Communications Systems. The equipment used with the 48-inch (122 cm) telescope will support the R&D effort and operations for the DOD/NASA Space Laser Communications experiments.

2. Construction of Mezzanine Addition to Shop Area, Building 5, in the Instrument Construction and Installation Laboratory 115,000

This project proposes the construction of a mezzanine in the existing tool crib serving the Machine and Sheet Metal Shops. An additional 800 sq. ft. (74 sq. m) of available area for tool custody will be constructed. Also included will be the extension of the heating, ventilating and air conditioning system. The consolidation of the Machine and Sheet Metal Shops has forced both organizations to share a tool crib formerly used by only one shop. The crib is inadequate in size and must be expanded.

D. Jet Propulsion Laboratory 570,000

1. Addition to Remote Preparation Building, Building E-44, Edwards Test Station 105,000

This project provides for the construction of a 500-sq. ft. (46 sq. m) addition to an existing propellant preparation building at Edwards Test Station. Construction is concrete slab, block walls, standard roofing, plus temperature and humidity controls. The present building, of similar construction, contains 323 sq. ft. (30 sq. m) and was built in 1963. It is not of adequate size to house the newer machine tools used to remotely prepare the cast solid propellant grains for testing. Remotely operated

mandrel pulling (from the casting) and propellant machining equipment, necessary to prepare the larger propellant grains, will be installed in the new addition. This additional area is required for research oriented activities in the development of solid motors of up to 18,000 pounds thrust. The addition is also required to provide testing capabilities for solid propellants in a remote area which is necessary to preclude a compromise of safety standards.

2. Construction of a Radiographic Inspection and Assembly Building, Edwards Test Station 225,000

This project provides for the construction of a new high bay building at Edwards Test Station for radiographic inspection of propellant grains. The building is approximately 1,000 sq. ft. (93 sq. m) with 40 ft. (12 m) head room plus an adjacent low bay control area. Construction is concrete slab on grade, block walls and an overhead three ton crane. The high bay will accommodate X-ray equipment able to penetrate a 4,000-pound propellant grain which will be operated from the adjacent control area. Access roads, utilities and fence relocation are included in the site development per the master plan. The present facility cannot handle motors over 800 pounds. Private off-site vendors have been utilized for this class work but they are all now closed, or closing, and no place is available for essential X-ray tests preparatory to firing. Without X-ray examination for voids or blow holes, dangerous explosions can occur during firing tests with resultant facility and equipment destruction as well as hazardous exposures to personnel.

3. Addition to Facility Engineering Office Building, Building 200 240,000

This project proposes a 5,250-sq. ft. (488 sq. m) two-floor addition to the Facility Engineering Office Building, Building 200. This addition will allow for needed loading and maintenance shop space on the first floor. The second floor will provide space for new offices and will consolidate those personnel in temporary and remote locations at the site. This addition will provide for better utilization of space and increase the efficiency of the engineering office.

E. Johnson Space Center 185,000

1. Construction of Storm Drainage System, Thermochemical Test Area (TTA) 185,000

This project provides for the construction of a storm drainage system in the Thermochemical Test Area (TTA). This is phase I of a two-phase project and consists of regrading three existing drainage ditches, installing storm sewers and inlets, contour grading of drainage areas, and seeding the regraded areas. The existing drainage consists of small road ditches and three secondary drainage ditches which are poorly graded and inadequate in cross section. Poor drainage exists causing the flat area to contribute to widespread ponding of rainwater and subsequent long periods of wetness. This hampers TTA operations, restricts mowing operations and encourages the breeding of mosquitoes. Silting has also caused obstructions and ponding in the secondary ditches. This project will reduce maintenance of the roads and

keep the area from flooding during storms. The future phase II will consists of similar work in an area north of the TTA area and it is estimated that the cost will be $200,000.

F. Langley Research Center 865,000

1. Construction of Addition to Flight Instrument Laboratory, Building 1202 225,000

This project provides for construction of an addition of approximatley 5,000 sq. ft. (465 sq. m) to the Flight Instrument Laboratory, Building 1202. This addition consists of enclosing the southwest corner of the building with the construction similar to the existing building. The area will be divided into three large rooms for instrumentation systems assembly, and for housing of hybrid multispectral processor and image generation equipment, and six smaller rooms for individual sensor development and calibration laboratories. Existing heating and air conditioning capabilities will be extended and no unique utilities are required.

These facilities are required for laboratory evaluation of earth resource sensors and data preprocessing concepts being developed under the Advanced Applications Flight Experiment and Space Research and Technology Progams, and for assembly of these sensors into instrumentation systems for evaluation via aircraft flight tests. During CY 1978 and subsequently, ground and flight tests on sensor instruments developed in these programs will be conducted. These instruments will be the pre-prototypes of next generation air and water quality instrumentation.

2. Construction of Logistics and Property Management Building 215,000

This project provides for the construction of a one-story masonry structure of approximately 4,000 sq. ft. (372 sq. m) to be located on Durand Road near the General Storage Building 1245. The building will include minimum partitions with large open landscaped spaces that provide maximum flexibility for approximately 30 people. This work will also include the necessary rest rooms, mechanical equipment and parking area. A study of the property management and stores functions indicated that the consolidation will improve the overall effectiveness and efficiency of this organization. The study indicates the manpower savings can amount to five manyears per calendar year with this new facility. This centralized location for this facility will provide for effective supervision of these functions, more efficient operations, and improved coordination with other Center functions.

3. Construction of Addition to Data Systems Building, Building 1152 110,000

This project provides for the construction of a single story addition of approximately 1,800 sq. ft. (167 sq. m) at the north corner of the Data Systems Building, Building 1152. The work will include acoustic tile ceiling and carpeted floor to reduce the noise level for key punch operations. Storage will be provided for computer card stock and standard forms. The addition is required to provide space

for production key punch operations and computer supplies. This addition is needed to replace three trailers which are providing an interim solution to the requirement. These trailers limit security and the effectiveness of the operation, and are inefficient to operate and maintain. The data processing systems support all programs and operations at the Center.

4. Construction of General Services Facility 245,000

This project provides for the construction of a 6,000-sq. ft. (558 sq. m) one-story masonry block structure, to be located east of the intersection of Bush and Freeman Roads. This work will include an office area and a one-story shop area. Rest room facilities and storage space will be provided in the shop area. This building is needed for the service organizations of the Plant Engineering Division. At present they are located in four trailers and in shop and office space in the Model Shop, Building 1150. The trailers are planned for disposal and Building 1150 is deteriorated, inadequate, and scheduled for demolition.

5. Construction of Aircraft Crashworthiness Preparation Building 70,000

This project provides for the construction of a one-story pre-engineered metal building of approximately 2,400 sq. ft. (223 sq. m) in the vicinity of the Impact Dynamic Research Facility, Building 1297. The building will include a 42-foot (12.9 m) wide hangar type door and an 18-foot (5.5 m) ceiling height. A hoisting mechanism will be located overhead for the suspension of aircraft. This building is required to provide environmental protection for aircraft prior to testing. This building will be used for the installation and calibration of instrumentation, and post-test evaluation of aircraft being prepared for crash testing. The building will also provide an area for weighing and balancing of aircraft. The major portion of this research support is now performed outside and is discontinued during rain or extreme cold weather.

G. Lewis Research Center 250,000

1. Construction of Storage Building for Equipment 115,000

This project provides for the construction of a pre-engineered metal building of approximately 4,800 sq. ft. (447 sq. m). in the vicinity of Substation A, Building 200. The building will be 40 feet (12.2 m) wide and 120 feet (36.6 m) long with a 16-foot (4.9 m) height erected on a reinforced concrete floor slab and foundation. The building will be insulated, heated and lighted. An overhead door will be provided at the south end. This building will be used to consolidate equipment catalogued in the agency-wide equipment storage system during the 120-day screening cycle. This equipment is presently dispersed at four locations at Lewis and at Plumbrook resulting in an inefficient and time consuming operation. The average inventory value of the items to be stored during the screening cycle is $1,500,000.

2. Construction of Coal Storage Area 135,000

This project provides for the construction of a coal storage area for 8,000 to 12,000 tons (7,257,600 to 10,886,400 kg) to be located in the vicinity of South and Substation A Roads. The site will be graded and a layer of acid neutralizing limestone will be installed over a drainage system of field tile. This tile will drain into a new retention basin which is necessary to hold the runoff from a 4-inch (10.2 cm) rainfall. The accumulated water will be treated prior to being pumped from the basin. A pre-engineered metal building of approximately 320 sq. ft. (28 sq. m) will be included to house the water pump and chemicals. A perimeter road with security lighting is included. The current and future critical shortage of natural gas combined with the economic disadvantages of using fuel oil mandates the use of coal as heating fuel. The proposed coal storage area accommodates the proper logistics of coal, delivery, storage, and consumption. The area will provide a six months supply of coal to meet anticipated delivery contingencies.

H. Wallops Flight Center 420,000

1. Construction of Storage Shed 190,000

This project provides a prefabricated metal storage shed 100' x 150' x 14' high (30.48 m x 45.72 m x 4.26 m high). The structure will be constructed using steel columns spaced at maximum possible spans with galvanized steel panels. This shelter is urgently needed to protect portable power generating systems containing sensitive electronic voltage regulators and controls from deterioration due to continuous long-term exposure to the elements.

2. Construction of Environmental Protection for Support Equipment 230,000

This project provides for construction of a 9,120-sq. ft. (847 sq. m) metal building consisting of five bays, including a high bay with a 26-foot high (7.92 m) door. This facility will provide protection from the salt environment for the mobilized equipment used to support launch range operations.

I. Various Locations 1,245,000

1. Construction of a 9-Meter Antenna at Madrid, Spain 235,000

This project will relocate a 9-meter (30 ft.) antenna to the Madrid Station. The construction includes: antenna foundation, boresight tower foundation and guy anchors, a hydro-mechanical building, power and signal trenching, necessary road accesses, and antenna service apron. The station's grounding, fire detection/protection and electrical systems will be extended as necessary.

The project will provide a simultaneous S/Ku-band capability in the post 1979 period to support S-band and Ku-band equipped satellites. This support is required for all synchronous and elliptical orbiting spacecraft.

2. Construction of a 9-Meter Antenna at Rosman, North Carolina 245,000

This project will relocate a 9-meter (30 ft.) antenna from Carnarvon to Rosman. The construction includes: antenna foundation, boresight tower foundation and guy anchors, a hydro-mechanical building, power and signal cable trenching, neccessary road accesses, and antenna service apron. The station's grounding, fire detection/protection and electrical systems will be extended as necessary.

The requirement exists to provide the Rosman Station with a full Unified S-Band capability and a simultaneous S/Ku-band operational capability. It will also permit removal and disposal of the obsolescent dual 14-foot (4.5 m) system which currently provides S-Band command and ranging at the Rosman Station.

3. Construction of a 9-Meter Antenna at Merritt Island (MILA), Florida 140,000

This project will relocate an existing 9-meter (30 ft.) antenna at the Merritt Island (MILA) Station. The construction includes; antenna foundation, boresight tower foundation and guy anchors, a hydro-mechanical building, power and signal cable trenches, necessary road accesses, and antenna service apron. The stations grounding, fire detection/ protection and electrical systems will be extended as necessary.

The two existing 9-meter antennas at MILA are located south of the Operations Building and have their key-holes aligned in a north-south direction. To provide the versatility necessary to support missions in the shuttle era, it is proposed to move one antenna east of the Operations Building and to align its key-hole in a east-west direction. This flexibility was not necessary in the pre-shuttle era.

4. Construction of Support Facilities for Mobile Lasers, Various Locations 355,000

This project will provide for the construction of two laser sites at various sites around the world. The construction includes land clearing as necessary, road construction, erection of temporary shelters, and pouring of concrete pads for the laser tracking systems. Sanitation facilities will be included.

Each site will be managed as a separate project because of the different locations involved. The estimated cost to construct these facilities at these locations ranges from $150,000 to $200,000. This is the third increment of Laser Tracking Sites for the Laser Geodynamic Satellite (LAGEOS) projects. The first two increments were funded in FY 1975 and FY 1976.

These Laser Tracking Systems will be used in conjunction with the LAGEOS and other operational application spacecraft. They will comprise part of a global network of highly accurate tracking stations in tectonically unstable areas. By precisely tracking these spacecraft and discerning very small changes in the ranging measurements over a period, these stations will participate in the observing and analyzing of tectonic plate motions. This will contribute to man's knowledge and understanding of the earth's surface motion. The objective of this undertaking is to contribute to earthquake prediction and possible geological exploration. These sites will be occupied periodically for short periods over several years while the tracking observations are made. In this manner, a minimum of laser tracking systems will be required.

5. Construction of Antenna Service Tower at Fairbanks, Alaska 210,000

This project will provide an enclosed telescoping tower to elevate service personnel and equipment approximately 15.2 meters (50 ft.) for maintenance work on the 26-meter (85 ft.) antenna.

Maintenance work on the antenna feed box must be performed during the winter months when temperatures range as low as -51°C. Work is presently performed from a cherry picker and workers are exposed to the elements of this severe climate. The cherry picker tends to drift and is hard to control. Efficiency under these conditions is low and sometimes counter productive. A similar tower at the nearby National Oceanographic and Atmospheric Administration antenna has proven most beneficial with respect to improved efficiency and minimum down-time for repairs.

6. Construction of Flammable Storage Facility, Kauai, Hawaii 60,000

This project will provide approximately 1200 square feet (111.5 sq. m) single story masonry building and loading dock at the Hawaii Station. The station's fire detection/protection, grounding electrical systems and road access will be extended as necessary.

Space previously utilized for storage is being displaced to make room for electronic equipment and other operational functions due to the recent small antenna additions. This project is considered necessary to restore adequate space for the storage of bulk items and equipment, to centralize staging of logistics and handling of supplies and equipment now scattered throughout the station and to provide a storage area for flammable materials.

MISCELLANEOUS PROJECTS LESS THAN $50,000 EACH 625,000

TOTAL..... 5,125,000

FUTURE CoF ESTIMATED 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 1977 ESTIMATES

SUMMARY

FACILITY PLANNING AND DESIGN

	Amount	Page No.
Regular Requirements:	5,155,000	
Master planning	200,000	CF 12-2
Engineering support	995,000	CF 12-3
Preliminary engineering reports and related engineering studies	1,110,000	CF 12-4
Final design	2,850,000	CF 12-5
Other Requirements:	7,500,000	
Shuttle facility planning and design	2,900,000	CF 12-6
Spacelab/payloads planning and design	800,000	CF 12-7
Large aeronautical facilities	3,800,000	CF 12-8
Total	12,655,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1977 ESTIMATES

PROJECT TITLE: Facility Planning and Design		
	FY 1977 CoF ESTIMATE: $12,655,000	
FY 1975: $10,900,000	FY 1976: $9,275,000	TQ: $2,500,000

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.

The $12,655,000 requested for facility planning and design for FY 1977 is composed of two major segments:

a. Regular requirements - $5,155,000

b. Other requirements - $7,500,000

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. Much of 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 5,155,000

A. Master Planning 200,000

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 3-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 1977 are:

(1) Jet Propulsion Laboratory

A major update of the existing master plan to include facility modifications, the recent land acquisition, and the post-VIKING utilization of facilities.

(2) Kennedy Space Center

A major update to include new space-shuttle and shuttle-related facilities, revisions in utilization, and the general updating of the existing plan.

(3) Johnson Space Center

A scheduled update to include orientation to space shuttle needs and revised utilizations of facilities.

(4) Wallops Flight Center

A major update to involve consolidation of facilities and the attainment of the posture of a more efficient utilization of facilities.

B. Engineering Support 995,000

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 1977. These efforts are of upmost importance due to the more unpredictable cost situation which currently exists, and cost trends in construction materials, fuels, and the operation and maintenance cost for the physical plant. This also includes provisions for maintaining a current engineering data base and updated construction specifications for utilization by the various field installations. The following items are included in the FY 1977 requirements.

(1) Building Research and Advisory Board Support

This covers annual support to the Federal Construction Counsil (FCC) operations and provides for special studies that this Council will perform throughout FY 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, National Academy of Sciences, and its activities are supported by several Federal agencies including NASA.

(2) 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 utility supply problems.

(3) Design Specifications Update and Support

This provides for the continuation of engineering services for the updating and functioning of 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.

(4) 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 a source of basic 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 revised, the handbook must accordingly be modified on a progressive basis.

(5) Facility Operation and Maintenance Analysis

This provides for continued engineering support in implementing, at field installations, improvements relative to manpower utilization, work control systems, preventive maintenance, and facilities management and reporting. This also includes some facility operation and maintenance management surveys to be conducted on a priority basis, at selected NASA field installations.

(6) 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 buildings, coincident with the 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 validated. This is an extension of an existing program to develop substantive energy conservation design criteria and operational procedures for existing standard-type buildings at NASA installations.

C. Preliminary Engineering Reports and Related Engineering Studies 1,110,000

(1) Preliminary Engineering Reports (PER's) (740,000)

Preparation of PER's, investigations, and project studies related to proposed facility projects to be included in the FY 1979 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 an 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 $25 million to $30 million for which completed new PER's will be required.

(2) Related Engineering Studies (370,000)

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 2,850,000

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 1978 Construction of Facilities program. This request will provide for final design work associated with such proposed subsequent construction of this nature estimated to cost $45 to $50 million. It will also provide for residual requirements of this nature which have accumulated from prior years' final design activities.

2. OTHER REQUIREMENTS 7,500,000

These other facilities planning and design requirements are generated by potential future projects, large in size and of a complex nature. Those in this particular request are primarily associated with future space programs which require a long planning cycle. Early and progressive design work is essential to ensure the ultimate best design, cost estimates and schedules. These projects then require 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 — 2,900,000

(1) Shuttle Facilities Studies and Preliminary Design — (390,000)

This portion of the total Space Shuttle facility requirements is associated with the preparation of preliminary engineering reports (PER's), the conduct of facilities investigations, and studies for facilities projects which in most cases will be included in the FY 1979 Construction of Facilities program. This preliminary work is predominantly associated with future construction for that year now estimated to cost approximately $50-55 million and which is to be carried out in relation to Space Shuttle unique projects such as:

(a) Launch and Landing Facilities

Additional studies will be conducted and PER's will be implemented involving modification of existing facilities, to satisfy launch control and mission control requirements at the Kennedy Space Center and Johnson Space Center, respectively, and the construction and modification of facilities at the launch site to support the increased flight rates planned for the operational phase. These higher rates will place demands on ground support equipment which was, in many cases, designed to support the less frequent launches of the Apollo program. In order to understand the extent and impact of this increased demand, additional studies must be undertaken. In addition, several projects which were provided for in previous years require additional study to investigate and resolve problems which have emerged as programmatic testing and design have been completed. Examples of emerging problems are those connected with higher sound levels at the launch pad, total integration and insertion of the payload, and emergency egress from the launch pad and Orbiter.

(b) Solid Rocket Booster and External Tank Facilities

Studies and PER's will be continued toward modifying existing facilities or providing added capabilities for Solid Rocket Booster production as they relate to satisfying increased production requirements. As in the launch facilities, additional requirements may be emerging in relation to production of the external tank. The requirements must be studied to determine appropriate facility solutions which may have an impact on projects previously provided for. An example of an emerging problem is the need for additional facilities to support increased thermal protection being applied to the external tank.

The cost of these related studies is estimated at $150,000 and the estimated cost of preparing preliminary engineering reports (PER's) is $240,000.

(2) Shuttle Facilities Final Design (2,510,000)

This portion of the total facility planning and design required for Space Shuttle facilities is associated with the preparation of final design, drawings and specifications required for future construction of Space Shuttle facilities, now estimated to cost approximately $60-65 million and which may be included in an FY 1978 Construction of Facilities request. The final design costs relating to the proposed FY 1978 projects will be somewhat reduced from that ordinarily expected since some of the projected construction is similar to facilities already designed and under construction. 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 rates of the operational phase. Facilities for which projects are forecast during 1978 include modification to the second launch pad, mating integration and checkout facilities, and development of logistics support facilities. Also included is design for enlargement of external tank production facilities at Michoud Assembly Facility (MAF) required to support the greater production rates.

B. Spacelab Payloads Planning and Design 800,000

This planning requirement is related to the study, preliminary engineering and final design of facilities to support the Spacelab and Payloads programs. These programs are essential to provide the capability for developing, integrating and checking out scientific application, technology and upper stage payloads as well as the capability to launch these payloads in the Space Shuttle vehicle. As flight rates increase, special payloads requirements may require additional facilities to support specialized or functionalized activities. In addition, requirements for facilities to support ground control of payload missions must be assessed. The facilities considered for construction are now estimated to cost $10 million to $15 million and will be needed in the FY 1978 and subsequent Construction of Facilities programs. The cost of these studies and preliminary engineering effort required in FY 1977 is estimated at $250,000 and the final design is estimated at $550,000.

C. Large Aeronautical Facilities Planning and Design — 3,800,000

(1) Final Design for National Transonic Facility — (3,400,000)

This planning is required for obtaining final facility design relating to the construction of a National Transonic Facility (NTF) with a high Reynolds number capability. The Aeronautics and Astronautics Coordinating Board has recommended that a single facility be built at the Langley Research Center to satisfy both the research requirements of NASA and the development needs of the U.S. Air Force. The proposed facility will provide for aerodynamic research and development on aircraft over a Mach number range from 0.2 to 1.2 and at Reynolds numbers up to about 120 million. The proposed facility will be capable of cryogenic operation which permits major reductions in model loads and in tunnel power requirement. It will also permit separation of Reynolds number effects from aeroelastic effects, a capability unattainable in any known existing wind tunnels.

An initial $2,100,000 has been funded for engineering studies to more fully define operating conditions and cost parameters and to initiate final design. Included in NASA's Construction of Facilities request for FY 1977 is a project for $25 million to initiate procurement of the long-lead time items for the NTF. It is planned that NASA will request some $40 million to complete the construction of this National Transonic Facility in following future years programs. It is anticipated that this request will complete all the facility planning and design work for the NTF.

(2) Final Design for Modification of the 40 x 80-Foot Subsonic Wind Tunnel (Phase II - Addition of 80 x 120-Foot Test Section Leg) — (400,000)

This project has been divided into two phases: (a) Repowering; and (b) Addition of 80 x 120-Foot Test Section Leg. The final design of the repowering phase has been funded and a major portion of the design is complete. A total of $1,810,000 has been funded for engineering studies, final design of the repowering phase, and for preliminary design of the new test section addition.

This request is for $400,000 and will provide for acoustic studies to determine the most cost-effective approach to be used in the design of the acoustic baffle system for the new test section addition and to continue with some final design of the new test section addition.

It is planned that NASA will request some $44 million for the repowering phase and approximately $50 million for the addition of the new test section leg in future year's programs. It is anticipated that an additional $1.2 million of Facility Planning and Design funds will be required in a future year to complete all the facility planning and final design work for the addition of the new test leg.

Total	12,655,000

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1977 ESTIMATES

GENERAL STATEMENT

The Research and Program Management appropriation provides for (1) the civil service staff needed to perform in-house research, technology, and test activities; 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 including travel and transportation, maintenance, and operation of facilities; and technical and administrative support. Over three-fourths of this appropriation is required to cover salaries and related costs of civil service employees. The balance, consisting of travel, facilities services, technical services, and administrative support of all NASA installations, provides the support and related goods and services which make possible the efficient accomplishment of NASA's approved missions.

The future of our aeronautics and space activities depends on the strength of our most important resource -- the approximately 24,000 civil service personnel 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 assure overall effectiveness and economy in our field operations, the responsibility for planning and direction of NASA's field center operations is consolidated in one senior line official, the Associate Administrator for Center Operations.

Institutional Assessment

During the past year, NASA conducted an institutional assessment consisting of an analysis of the distribution of program responsibility and manpower within the NASA centers and the Jet Propulsion Laboratory. Although program reviews and their institutional impact are a regular function of the budget process, the institutional assessment conducted this year was focused on the transition of institutional activity into the Shuttle era.

The principal thrust of the study was to clarify the roles and missions of the NASA centers and JPL. This resulted in some program consolidations and realignments. The implementation of these actions will begin in FY 1977 and continue through FY 1979 and consist of the following:

- Consolidate the number of centers involved in free flyer development management with the major role focused at the Goddard Space Flight Center.

- Consolidate most future planetary work involving spacecraft development management and flight control at the Jet Propulsion Laboratory.

- Streamline Shuttle operations, with all flight operations (except free flyers) focused at the Johnson Space Center and all ground operations (including experiment and cargo integration) for the Shuttle accomplished at the Kennedy Space Center.

- Consolidate supporting research and technology work consistent with principal roles of the centers and the competence of the people.

- Clarify and consolidate the aeronautical roles of the Ames Research Center and the Langley Research Center.

The decisions on program modifications and the resulting impact on manpower are reflected in the FY 1977 budget.

SUMMARY OF 1976 CURRENT ESTIMATE AND 1977 ESTIMATE
(Thousands of Dollars)

	1976 Current Estimate	Transition Quarter Current Estimate	1977 Estimate
Budget request	776,000	213,800	
Congressional action	-488	-122	
Appropriation	775,512	213,678	
Plan prior to October 1975 pay raise	775,512	213,678	787,000
Effect of October 1975 salary rates	+19,986	+7,117	+27,055
Plan based on October 1975 salary rates	795,498	220,795	814,055
Proposed supplemental appropriation to cover FY 1976 deficiency	19,986	7,117	

Summary of Obligations by Function

The table below summarizes requirements by functional category:

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Personnel and related costs.....	587,954	597,513	592,007	156,759	155,921	588,575
Travel.....	15,392	17,001	17,870	5,065	5,146	17,143
Facilities services.....	83,286	85,590	85,489	28,850	29,449	98,005
Technical services.....	33,983	33,871	34,377	10,230	10,448	36,976
Administrative support.....	44,089	42,025	45,769	12,896	12,714	46,301
Subtotal.....	764,704	776,000	775,512	213,800	213,678	787,000
October 1975 pay raise.....	---	---	19,986	---	7,117	27,055
Total.....	764,704	776,000	795,498	213,800	220,795	814,055

Summary of Changes - 1976

The changes which have occurred in the 1976 plan since the submission of the budget and the current estimate in the 1977 budget can be summarized as follows:

1. The effect of congressional action which reduced the request by $488,000, to $775,512,000 for R&PM, reflects a ten percent reduction in GSA building rental rates.

2. The internal adjustments to the budget estimates to accommodate unanticipated cost increases. These changes result in no overall increase to the plan, but represent significant changes within the plan. The following represent the major increases in cost which have occurred since the 1976 budget was submitted:

a. Utility rate increases not offset by consumption reductions..... +5.4 million

b. 1976 increases in contractor wage rates..... +4.3 million

c. Increase in per diem and mileage rates..... +2.0 million

Total of major unanticipated cost increases..... +11.7 million

Offsetting these increases, reductions in the level of service, delays in personnel actions and decreases in the purchase of supplies, equipment and miscellaneous services have been necessary. The major decreases are:

a. A reduction of about 260 manyears in the level of support services contractor effort..... -3.7 million

b. Revisions to the civil service personnel plan for 1976..... -5.5 million

c. Reduction in the number of travel trips..... -1.1 million

d. Reductions in the purchase of supplies, equipment and other services..... -1.4 million

Total of cost reductions to offset unanticipated cost increases..... -11.7 million

3. The increase in costs related to the five percent service pay raise effective in October 1975. The estimated cost of this increase, based on the current personnel plan, is $19,986,000, for which no provision was made in the 1976 budget estimate, and for which a supplemental appropriation is being requested.

The revised R&PM budget plan for 1976, including the requested supplemental appropriation, is $795,498,000, an increase of $19,986,000 above that appropriated for 1976.

Summary of Changes - Transition Quarter

The current estimate of $220,795,000 for the transition quarter provides for continuation of activities at the 1976 level. The estimate reflects the reduction in GSA rental charges and a supplemental appropriation request of $7,117,000 to cover the October 1975 increased salary rates.

Summary of Changes - 1977

The budget for 1977 is $814,055,000, an increase of $18,557,000 over the revised plan for 1976. The 1977 estimate provides for the full year effect of increased utility rates, contract wage rates, and cost of materials, which continue to rise more rapidly than conservation efforts can offset. Personnel compensation estimates include the net cost of the full year effect of the October 1975 pay raise, offset by the effect of the reduction of 500 civil service positions.

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 1977 estimates provide for the full year cost of the October 1975 pay raise as well as the costs for within-grade advances and career development. These costs are partially offset by savings from a reduction of 500 civil service positions.

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 1977 estimates reflect the full year effect of programs to reduce travel costs instituted in 1976 to partially offset the cost of increased per diem and mileage rates.

3. Facilities Services includes rental of real property, the cost of maintenance and related services, custodial services, minor modifications, utilities and facility operations. The 1977 estimates provide for a full year's funding for certain support contracts and for the full year effect of contractor wage increases, utility rate increases and the higher supply and material costs, partially offset by a decrease in the level of support service contractor manyears.

4. 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 1977 estimates provide for a full year funding of support contracts and the full year effect of 1976 contractor wage increases, partially offset by a reduction in service contractor support.

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 increases shown for 1977 reflect full year costs of communications rate increases and a reduction in contractor effort.

The content of these functions is explained in more 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 23,816 at the end of 1977. The estimate for permanent compensation is based upon the position structure at the start of the year, as modified by the abolishment of positions, within grade advances, career development, and other changes occurring during the year.

b. Nonpermanent: The nonpermanent 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 has been a principal source of recruitment for young and experienced professional personnel. The program alternates work and study periods which provide the students with practical experience and academic training, and permits many students to attend college they could not otherwise afford by providing them an income during their work period.

The Summer Employment program employs high school and college students and faculty members in consonance with the Federal Government policies and objectives, and provides them an insight into Government operations, while providing the agency many 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 Detailees: 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 differential, and hazardous duty pay are included in this category.

2. Benefits:

In addition to compensation, NASA makes an employer's contribution to personnel benefits as authorized and required by law. These benefits include contributions to the Civil Service Retirement Fund, employees life and health insurance, and social security contributions for nonpermanent 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 severance pay are made to former employees involuntarily separated through no fault of their own.

B. SUPPORTING COSTS:

1. Transfer of Personnel:

Relocation costs, such as the expenses of selling and buying a home, and the movement 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 advertising, career-maturity surveys, and any requested investigation of formal discrimination complaints.

3. Personnel Training:

Training is provided within the framework of the Government Employees Training Act of 1958. Part of 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 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 throughout the entire United States, coordination and management of activities require frequent review by personnel 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. Meetings and Technical Seminars:

Travel to meetings 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.

C. Administrative Travel:

Administrative travel includes travel for the direction and coordination of general management matters and travel by senior officials 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.

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 government-owned or leased space including office buildings in Washington, DC, 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 operating.

C. Operation of Facilities:

1. Utilities:

This category reflects the cost of electricity, water, gas, and other utilities.

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 operational 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 libraries were established to provide information from books, periodicals, technical reports, and other documentation. The costs for these services are budgeted in this subfunction.

2. Educational/Information 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 commercial 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.

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DISTRIBUTION OF PERMANENT POSITIONS BY INSTALLATION

Installation	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
Johnson Space Center	3,632	3,613	3,613	3,613	3,613	3,613
Kennedy Space Center	2,259	2,259	2,259	2,259	2,259	2,259
Marshall Space Flight Center	4,113	4,113	4,113	4,113	4,113	3,925
National Space Technology Laboratories	70	70	70	70	70	70
Goddard Space Flight Center	3,753	3,754	3,747	3,754	3,747	3,675
Wallops Flight Center	416	415	415	415	415	414
Ames Research Center	1,678	1,676	1,676	1,676	1,676	1,613
Flight Research Center	490	489	497	489	497	497
Langley Research Center	3,309	3,332	3,330	3,332	3,330	3,172
Lewis Research Center	3,025	3,025	3,025	3,025	3,025	3,025
Headquarters	1,571	1,570	1,571	1,570	1,571	1,553
Total, Permanent Positions	24,316	24,316	24,316	24,316	24,316	23,816

SUMMARY OF OBLIGATIONS BY INSTALLATION
(Thousands of Dollars)

Johnson Space Center	121,332	125,196	128,189	34,966	36,139	134,254
Kennedy Space Center	95,918	94,974	97,411	29,753	30,469	103,624
Marshall Space Flight Center	129,050	130,506	133,442	34,372	35,662	133,165
National Space Technology Laboratories	1,623	1,696	1,767	423	442	1,833
Goddard Space Flight Center	104,767	105,847	108,591	27,740	28,837	109,176
Wallops Flight Center	12,376	12,705	13,054	3,543	3,638	13,654
Ames Research Center	48,571	49,257	50,561	12,749	13,188	50,518
Flight Research Center	13,246	13,714	14,097	4,907	5,048	15,832
Langley Research Center	88,642	90,710	92,922	23,387	24,319	91,691
Lewis Research Center	80,314	81,902	81,711	21,936	22,574	85,739
Headquarters	68,865	69,493	73,753	20,024	20,479	74,569
Total	764,704	776,000	795,498	213,800	220,795	814,055

SUM 12

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1977 ESTIMATES

RESEARCH AND PROGRAM MANAGEMENT

DISTRIBUTION OF PERMANENT POSITIONS BY PROGRAM

Program Office and Program	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
SPACE FLIGHT	7,346	7,581	7,437	7,581	7,443	7,349
Space shuttle	3,879	5,172	5,249	5,172	5,257	5,340
Space flight operations	2,808	1,700	1,488	1,700	1,486	1,332
Expendable launch vehicles	659	709	700	709	700	677
SPACE SCIENCE	2,686	2,451	2,578	2,451	2,578	2,222
Physics and astronomy	1,813	1,648	1,732	1,648	1,732	1,530
Lunar and planetary exploration	611	558	615	558	615	461
Life sciences	262	245	231	245	231	231
SPACE APPLICATIONS	1,754	1,694	1,704	1,694	1,704	1,797
AERONAUTICS AND SPACE TECHNOLOGY	5,613	5,652	5,760	5,652	5,754	5,797
Aeronautical research and technology	3,824	3,849	3,841	3,849	3,845	3,799
Space research and technology	1,789	1,803	1,919	1,803	1,909	1,998
TRACKING AND DATA ACQUISITION	832	878	864	878	864	878
TECHNOLOGY UTILIZATION	78	69	71	69	71	74
Subtotal, Direct Positions	18,309	18,325	18,414	18,325	18,414	18,117
Indirect Positions	6,007	5,991	5,902	5,991	5,902	5,699
TOTAL, PERMANENT POSITIONS	24,316	24,316	24,316	24,316	24,316	23,816

SUM 13

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1977 ESTIMATES
RESEARCH AND PROGRAM MANAGEMENT
DISTRIBUTION OF OBLIGATIONS BY FUNCTION BY INSTALLATION
(Thousands of dollars)

Function	NASA Total	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												
1975	587,954	92,640	53,629	105,469	1,598	86,920	8,303	39,877	10,903	73,961	69,535	45,119
1976 Budget	597,513	94,231	54,242	105,900	1,672	87,630	8,527	40,315	11,346	76,036	71,833	45,781
Current	611,993	98,000	56,022	107,735	1,736	90,440	8,815	42,027	11,548	77,861	70,715	47,094
Transition Quarter Budget	156,739	24,268	14,587	27,150	418	22,861	2,197	10,363	3,003	19,494	18,735	13,683
Current	163,038	25,441	15,303	28,315	434	23,990	2,292	10,802	3,144	20,426	18,663	14,228
1977 Current	615,630	99,339	57,977	106,273	1,802	89,679	9,104	41,409	11,821	76,283	73,324	48,599
Travel												
1975	15,392	3,104	1,543	1,928	25	2,251	265	847	221	2,001	983	2,226
1976 Budget	17,001	3,666	1,764	2,115	24	2,255	251	878	242	2,267	1,074	2,465
Current	17,870	3,316	2,231	2,205	31	2,439	270	1,196	256	2,463	1,005	2,458
Transition Quarter Budget	5,065	1,015	664	556	5	631	123	289	84	681	316	701
Current	5,146	1,015	664	582	8	631	123	347	84	675	316	701
1977 Current	17,143	3,558	2,430	1,905	31	2,288	274	1,080	262	1,952	905	2,458
Facilities Services												
1975	83,286	12,182	25,460	9,623	---	7,832	2,828	4,832	1,605	7,354	8,022	3,508
1976 Budget	85,590	13,110	24,488	9,601	---	9,194	2,920	5,618	1,609	7,172	7,773	4,105
Current	85,489	13,075	23,084	10,949	---	9,506	2,946	4,972	1,745	7,145	8,277	3,790
Transition Quarter Budget	28,850	4,964	8,961	3,143	---	2,474	877	1,403	1,500	1,890	2,538	1,100
Current	29,449	5,238	8,961	3,373	---	2,442	877	1,293	1,500	1,857	2,926	982
1977 Current	98,005	16,696	25,264	12,116	---	10,523	3,234	5,489	2,735	7,960	9,609	4,379
Technical Services												
1975	33,983	6,134	4,851	6,389	---	2,807	213	854	71	1,529	427	10,708
1976 Budget	33,871	6,707	5,180	6,919	---	1,914	274	632	76	1,202	406	10,561
Current	34,377	6,686	5,890	6,724	---	1,763	262	541	76	1,504	428	10,303
Transition Quarter Budget	10,230	2,156	2,190	1,870	---	508	17	127	52	380	144	2,786
Current	10,448	2,486	2,190	1,732	---	508	17	125	52	408	144	2,786
1977 Current	36,976	7,348	6,231	6,876	---	1,864	235	569	78	1,635	458	11,682
Administrative Support												
1975	44,089	7,272	10,435	5,843	---	4,957	767	2,121	446	3,797	1,347	7,304
1976 Budget	42,025	7,482	9,300	5,971	---	4,854	733	1,814	441	4,033	816	6,581
Current	45,769	7,112	10,184	5,829	---	4,443	761	1,823	472	3,949	1,286	9,908
Transition Quarter Budget	12,896	2,563	3,351	1,653	---	1,266	329	567	268	942	203	1,754
Current	12,714	1,959	3,351	1,660	---	1,266	329	621	268	953	525	1,782
1977 Current	46,301	7,293	11,722	5,995	---	4,822	807	1,971	936	3,861	1,443	7,451
TOTAL												
1975	764,704	121,332	95,918	129,050	1,623	104,767	12,376	48,571	13,246	88,642	80,314	68,865
1976 Budget	776,000	125,196	94,974	130,506	1,696	105,847	12,705	49,257	13,714	90,710	81,902	69,493
Current	795,498	128,189	97,411	133,442	1,767	108,591	13,054	50,561	14,097	92,922	81,711	73,753
Transition Quarter Budget	213,800	34,966	29,753	34,372	423	27,740	3,543	12,749	4,907	23,387	21,936	20,024
Current	220,795	36,139	30,469	35,662	442	28,837	3,638	13,188	5,048	24,319	22,574	20,479
1977 Current	814,055	134,254	103,624	133,165	1,833	109,176	13,654	50,518	15,832	91,691	85,739	74,569

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SUM 14

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

RESEARCH AND PROGRAM MANAGEMENT

For necessary expenses of research in Government laboratories, management of programs and other activities of the National Aeronautics and Space Administration, not otherwise provided for, including uniforms or allowances therefor, as authorized by law (5 U.S.C. 5901-5902); awards; [purchase (not to exceed one, for replacement only of one or more existing aircraft, at least one of which shall be an administrative-aircraft, which existing aircraft may be exchanged in part payment),] hire, maintenance and operation of administrative aircraft; purchase (not to exceed [ten] *nineteen* for replacement only) and hire of passenger motor vehicles; and maintenance and repair of real and personal property, and not in excess of $25,000 per project for construction of new facilities and additions to existing facilities, and not in excess of $50,000 per project for rehabilitation and modification of facilities; [$775,512,000] *$814,055,000*: *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, $213,678,000.] (*42 U.S.C. 2451, et seq.; Department of Housing and Urban Development—Independent Agencies Appropriation Act, 1976; additional authorizing legislation to be proposed.*)

RESEARCH AND PROGRAM MANAGEMENT

Program and Financing (in thousands of dollars)

Identification code 27-00-0103-0-1-999	Budget plan				Costs and obligations			
	1975 actual	1976 estimate	TQ estimate	1977 estimate	1975 actual	1976 estimate	TQ estimate	1977 estimate
Program by activities:								
Direct program:								
1. Space flight	326,157	340,219	97,382	348,084	329,997	340,219	97,382	348,084
2. Scientific investigations in space	117,798	117,734	31,696	114,184	117,722	117,734	31,696	114,184
3. Space applications	76,529	78,261	21,269	87,133	76,483	78,261	21,269	87,133
4. Space research and technology	-66,508	-79,301	23,093	75,354	66,631	73,301	23,093	75,354
5. Aeronautical research and technology	137,667	143,195	35,747	146,200	138,567	143,196	35,747	146,200
6. Supporting activities	40,045	42,787	11,608	43,100	40,307	42,787	11,608	43,100
Total direct program costs, funded	764,704	795,498	220,795	814,055	769,707	795,498	220,795	814,055
Reimbursable program:								
1. Space flight	1,386	5,706	1,402	6,745	1,324	5,706	1,402	6,745
2. Scientific investigations in space	129	105	27	74	171	105	27	74
3. Space applications	4,422	8,589	2,111	7,185	4,221	8,589	2,111	7,185
4. Space research and technology	1,705	1,404	372	1,882	1,627	1,404	372	1,882
5. Aeronautical research and technology	72	19	5	19	69	19	5	19
6. Supporting activities	179	3,889	958	3,820	171	3,889	958	3,820
7. Energy technology applications	99	2,283	536	4,368	95	2,283	536	4,368
Total reimbursable program costs	8,442	21,995	5,411	24,093	7,678	21,995	5,411	24,093
Total program costs, funded	772,746	817,493	226,206	838,148	777,385	817,493	226,206	838,148
Change in selected resources (undelivered orders)					-4,639			
10 Total	772,746	817,493	226,206	838,148	772,746	817,493	226,206	838,148
Financing:								
Receipts and reimbursements from:								
11 Federal funds					-5,161	-15,955	-8,038	-19,383
14 Non-Federal sources					-2,881	-6,040	-1,373	-4,710
25 Unobligated balance lapsing					171			
Budget authority					764,875	795,498	220,795	814,055
Budget authority:								
40 Appropriation					759,975	775,512	213,678	814,055
41 Transferred to other accounts					-52			
42 Transferred from other accounts					4,952			
43 Appropriation (adjusted)					764,875	775,512	213,678	814,055
44.20 Supplemental now requested for civilian pay raises						19,986	7,117	
Relation of obligations to outlays:								
71 Obligations incurred, net					764,704	795,498	220,795	814,055
72 Obligated balance, start of period					52,756	56,381	57,179	56,774
74 Obligated balance, end of period					-56,381	-57,179	-56,774	-56,829
77 Adjustments in expired accounts					-282			
90 Outlays, excluding pay raise supplemental					760,797	775,500	213,700	813,597
91.20 Outlays from civilian pay raise supplemental						19,200	7,500	403

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1977 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, 1975, was $899,163,000.

MISSION

The Lyndon B. Johnson Space Center (JSC) was established in November 1961 with the responsibility for 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 Space Shuttle program and the Earth Resources program.

With the completion of the lunar landing missions in December 1972, 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). ASTP, the first manned space mission with joint participation by the U.S. and U.S.S.R., was completed in July 1975. The joint mission successfully demonstrated rendezvous in space of two international vehicles, docking of those vehicles utilizing the new universal docking systems, and the transfer of crew members between the two vehicles.

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 which 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.

A major effort at JSC is the Earth Resources Program (ERP), which is a significant part of the experimental Federal Earth Resources Program. This activity involves remote sensing from aircraft, and the demonstration and evaluation of remote sensing instruments, and interpretive techniques. JSC also has responsibility for the demonstration and documentation of the applications of remote sensing systems on a simulated operational basis. In particular, this involves the Large Area Crop Inventory Experiment (LACIE) being undertaken with the Department of Agriculture and the National Oceanic Atmospheric Administration.

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 and continuing research on returned lunar materials. Life Sciences capabilities include in-flight experiments, flight crew monitoring, and development of physiological requirements for manned spacecraft systems. In the area of flight operation, JSC has extensive experience and capability for mission planning, and for the overall direction of flight control activities.

The application of NASA-developed space technology to the public domain 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 system that utilizes aerospace techniques toward the achievement of more energy efficient residential and commercial buildings.

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

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
I. Personnel and Related Costs	92,640	94,231	98,000	24,268	25,441	99,359
II. Travel	3,104	3,666	3,316	1,015	1,015	3,558
III. Facilities Services	12,182	13,110	13,075	4,964	5,238	16,696
IV. Technical Services	6,134	6,707	6,686	2,156	2,486	7,348
V. Administrative Support	7,272	7,482	7,112	2,563	1,959	7,293
Total, fund requirements	121,332	125,196	128,189	34,966	36,139	134,254

Distribution of Permanent Positions by Program

Direct Positions						
Space Flight						
Space shuttle	1,910	2,248	2,302	2,248	2,302	2,353
Space flight operations	619	296	208	296	208	190
Space Science						
Physics and astronomy	32	34	49	34	49	40
Lunar and planetary exploration	63	54	61	54	61	60
Life sciences	101	93	103	93	103	103
Space Applications	323	297	306	297	306	296

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
Aeronautics and Space Technology						
Aeronautical research and technology....	3	5	3	5	3	3
Space research and technology.....	31	36	31	36	31	18
Technology Utilization.....	10	5	10	5	10	10
Subtotal, direct positions.....	3,092	3,068	3,073	3,068	3,073	3,073
Indirect Positions						
Director and Staff.....	110	115	110	115	110	110
Administrative support.....	164	164	164	164	164	164
Research and technology support.....	266	266	266	266	266	266
Subtotal, indirect positions.....	540	545	540	545	540	540
Total, permanent positions.....	3,632	3,613	3,613	3,613	3,613	3,613
PERSONNEL AND RELATED COSTS						
I. PERSONNEL AND RELATED COSTS.....	92,640	94,231	98,000	24,268	25,441	99,359
Basis of Fund Requirements						
A. Compensation and Benefits						
1. Compensation						
a. Permanent positions.....	81,912	83,032	86,341	21,180	22,234	87,540
b. Nonpermanent.....	1,201	1,194	1,281	365	383	1,303
c. Reimbursable detailees.....	862	922	1,272	232	244	1,294
d. Overtime and other compensation.	773	1,081	849	270	283	872
Subtotal, compensation.....	84,748	86,229	89,743	22,047	23,144	91,009

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Benefits	7,408	7,542	7,912	2,051	2,127	8,005
Subtotal, compensation and benefits	92,156	93,771	97,655	24,098	25,271	99,014
B. Supporting Costs						
1. Transfer of personnel	96	110	68	20	20	110
2. Personnel training	388	350	277	150	150	235
Subtotal, supporting costs	484	460	345	170	170	345
Total, Personnel and Related Costs	92,640	94,231	98,000	24,268	25,441	99,359
1. Compensation	84,748	86,229	89,743	22,047	23,144	91,009
a. Permanent positions	81,912	83,032	86,341	21,180	22,234	87,540

The funds shown above will support 3,613 permanent positions in 1977. The increase in 1976 from the budget estimate to the current estimate, and in the Transition Quarter, is due to the October 1975 pay raise.

The 1977 estimate reflects the full year's cost of the pay raise. Permanent personnel staffing during 1977 will continue at the same level as in 1976.

Basis of Cost for Permanent Positions

In 1977 the cost of permanent positions will be $87,540. The increase from 1976 results from the following:

Cost of permanent positions in 1976		86,341
Cost increases in 1977		+3,493
Within grade advances and career development:		
Full year effect of 1976 and Transition Quarter actions	+1,431	
Partial year effect of 1977 actions	+856	
Full year's effect of October 1975 pay raise	+1,206	

Cost decreases in 1977	-2,294
Turnover savings:	
Full year effect of 1976 and Transition Quarter actions	-925
Partial year effect of 1977 actions	-1,045
One less paid day in 1977	-324
Cost of permanent positions in 1977	87,540

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
b. Nonpermanent:						
Cost	$1,201	$1,194	$1,281	$365	$383	$1,303
Manyears	175	175	185	60	60	185

The 1977 plan includes 185 manyears, the same as 1976, which will be used to support the following programs:

Programs	Manyears
Cooperative training programs	75
Summer programs	41
Youth opportunity programs	47
Other temporaries	22
Total	185

The increase from the 1976 budget estimate to the 1976 current estimate is due to the October 1975 pay raise and the increase of ten manyears in JSC's cooperative training program. The cost of increasing the number of co-ops has been partially offset by a change in the mix of the other nonpermanent programs.

c. Reimbursable detailees	862	922	1,272	232	244	1,294

The military personnel detailed to the Johnson Space Center on a reimbursable basis are individuals experienced in manned flight and related fields. Each individual performs an essential and critical function to the current and future programs.

Individuals with knowledge, experience and with a "flight" background, are essential to the manned flight programs. The individuals most readily available within the Government ranks are in the military. The additional requirement for keeping the military informed on manned space flight technology is also essential. This is the basis for utilizing military detailees on a reimbursable basis.

One civilian employee, experienced in the field of medicine, is also detailed, on a reimbursable basis, to the Johnson Space Center. The 1976 current estimate is increased over the 1976 budget estimate due to the addition of 21 Air Force detailees in support of the Shuttle program. The number of detailees will be the same in 1977 as in 1976.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
d. Overtime and other compensation...	773	1,081	849	270	283	872

Overtime in FY 1977 will be used primarily for the Shuttle Approach and Landing Tests, e.g., crew training, trajectory optimization, data reduction, integration laboratory, and related support activities. In addition, there are numerous source selection boards, Earth Resources LACIE Program large operational demonstration phase and other activities that necessitate some extension of the normal work day or week.

The decrease in 1976 from the budget estimate to the current estimate is due to the careful examination of all overtime requirements by the JSC management. This more than offset the effect of the October 1975 pay raise. The increase in 1977 is due to the full year's cost of the pay raise.

2. Benefits.....	7,408	7,542	7,912	2,051	2,127	8,005

Following are the amounts of contribution by category:

Category of Costs						
Civil Service Retirement Fund....	5,757	5,877	6,070	1,666	1,742	6,161
Employee life insurance.....	307	260	379	66	66	375
Employee health insurance.....	1,239	1,300	1,350	304	304	1,354
FICA.....	44	50	48	10	10	50
Incentive awards.....	61	55	65	5	5	65
Total.....	7,408	7,542	7,912	2,051	2,127	8,005

The current estimate for 1976 is increased from the 1976 budget estimate to account for the higher government contribution to employee life insurance and employee health insurance; and the effect of the October 1975 pay raise.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
B. Supporting Costs	484	460	345	170	170	345
1. Transfer of personnel	96	110	68	20	20	110

The decrease from the 1976 budget estimate to the 1976 current estimate is due to a change in the planned phasing of transfers. The increase in 1977 reflects the addition of the 1976 delayed moves, and also contains funds for the relocation of personnel for the Shuttle program Approach and Landing Tests.

2. Personnel Training	388	350	277	150	150	235

Career development is a prime objective to permit employees to advance to more responsible positions. This also provides the Center with more highly motivated and experienced personnel. The decrease in 1976 reflects current training plans consistent with skill and program requirements. The 1977 decrease reflects the full year effect of implementation of the revised plan.

TRAVEL

II. TRAVEL	3,104	3,666	3,316	1,015	1,015	3,558

Approximately 80% of the total JSC travel estimate in FY 1977 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 examination by personnel responsible for the program. The Space Shuttle program travel requirements predominate; comprising approximately 70% of the total program travel.

The decrease in travel from the 1976 budget estimate to the 1976 current estimate is the result of re-evaluating JSC's travel requirements. It was found that by carefully examining each requirement, and by making use of travel substitutes such as teleconferencing, that certain economies in travel would occur. The increase in program travel from the 1976 current estimate to the 1977 budget estimate is due partially to the hardware reviews and critical configuration monitoring taking place between the three centers heavily engaged in the Shuttle development, and the Approach and Landing Test. These increases are partially offset by a decrease related to the completion of the Apollo Soyuz Test Project. Activities related to the reporting

of the results of the Apollo Soyuz Test Project, earth observation programs, and lunar samples, constitute the majority of requirements in the Meeting and Technical Seminar category. The dissemination of space technology information to the scientific sector also contributes to these requirements.

Basis of Fund Requirements

Summary of Travel by Major Category

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
A. Program travel	2,509	3,057	2,713	837	837	2,913
B. Meetings and technical seminars	146	179	156	49	49	166
C. Administrative travel	449	430	447	129	129	479
Total	3,104	3,666	3,316	1,015	1,015	3,558

FACILITIES SERVICES

III.	FACILITIES SERVICES	12,182	13,110	13,075	4,964	5,238	16,696

Basis of Fund Requirements

Summary of Facilities Services

A. Maintenance and Related Services						
1. Maintenance, repair and alteration of buildings and grounds	5,292	5,340	4,192	1,675	1,691	5,932
2. Custodial services	2,830	3,216	3,066	1,789	1,678	3,353
3. Maintenance of equipment	230	403	341	150	92	369
Subtotal	8,352	8,959	7,599	3,614	3,461	9,654

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
B. Operation of Facilities						
1. Utilities	2,864	3,151	4,627	1,070	1,517	6,037
2. Supplies and equipment	966	1,000	849	280	260	1,005
Subtotal	3,830	4,151	5,476	1,350	1,777	7,042
Total, Facilities Services	12,182	13,110	13,075	4,964	5,238	16,696
A. Maintenance and Related Services	8,352	8,959	7,599	3,614	3,461	9,654
1. Maintenance, repair and alteration of buildings and grounds	5,292	5,340	4,192	1,675	1,691	5,932

This activity provides for maintenance, repair, and alteration of buildings, grounds and utility systems at the Johnson Space Center and the White Sands Test Facility. This service provides only cyclic maintenance and minor breakdown repair. Approximately 252 manyears of effort are required to maintain: 214 buildings, that have an average age of 12 years, containing 3,032,000 square feet of space; 868 acres of improved ground and 216 acres of surfaced areas; 205,000 linear feet of water line, 18,720 linear feet of sewage, and drainage lines; 203,000 feet of electrical distribution lines and 18,720 linear feet of utility tunnels.

The decrease from the 1976 budget to the current estimate reflects a reduction of seven manyears, and a reduction to the minimum obligation required in 1976 in order to provide funds for increased cost rates for utilitites and services above those anticipated in the 1976 budget. The 1977 amount reflects a return to full-year funding for maintenance, repair and alteration at the current level of support.

2. Custodial Services	2,830	3,216	3,066	1,789	1,678	3,353

The security service includes badging of personnel and visitors, and policing of traffic involving approximately 13,000 vehicles daily. This support service contractor also provides 24-hour fire fighting and ambulance service to JSC. The custodial services contractor maintains approximately 2,555,465 square feet of area, periodically replaces 90,000 lights, and provides pickup daily of 144 cubic yards of trash.

The decrease from the 1976 budget estimate to the current estimate reflects a reduction of 22 manyears, partially offset by increased support contractor wage rates. The increase for 1977 is due to the full year effect of higher support contractor wage rates.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
3. Maintenance of Equipment.....	230	403	341	150	92	369

The change from the 1976 budget and Transition Quarter to the current estimates is due to a reduction of one manyear and an actual decrease in the equipment maintenance and repair requirements due to the replacement in 1975 of some equipment that was scheduled for maintenance and repair in 1976 and Transition Quarter. The increase in 1977 is attributable to support contractor wage increases.

B. Operation of Facilities	3,830	4,151	5,476	1,350	1,777	7,042
1. Utilities.....	2,864	3,151	4,627	1,070	1,517	6,037

The cost of natural gas per thousand cubic feet has increased from 30 cents in January 1973 to $1.86 in October 1975, for a cost escalation of 520 percent. Of the total increase in 1976, 94 percent is due to the increase in the natural gas rates and the remainder of the increase reflects increased electricity rates. The 1977 estimate provides for the same level of consumption at the increased rates, and for the purchase of surface water starting in early calendar 1976.

2. Supplies and equipment.....	966	1,000	849	280	260	1,005

The change from the 1976 budget estimate to the current estimate reflects a reduction in the supplies and equipment replacement in order to provide funds for increased rates for utilities. The funds for the Transition Quarter provide for services at the 1976 level. The increase in 1977 provides for the normal supply requirements level.

TECHNICAL SERVICES

IV. TECHNICAL SERVICES.....	6,134	6,707	6,686	2,156	2,486	7,348

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Basis of Fund Requirements						
Summary of Technical Services						
A. Automatic Data Processing						
1. Equipment	1,829	2,026	2,326	550	622	2,034
2. Programming and operations	2,321	2,239	2,280	605	704	2,920
Subtotal	4,150	4,265	4,606	1,155	1,326	4,954
B. Engineering Services	363	447	331	120	96	390
C. Scientific and Technical Information and Educational Programs						
1. Technical library	70	82	74	25	21	77
2. Educational/informational programs	450	499	453	140	166	487
3. Scientific and technical information	1,101	1,414	1,222	716	877	1,440
Subtotal	1,621	1,995	1,749	881	1,064	2,004
Total, Technical Services	6,134	6,707	6,686	2,156	2,486	7,348
A. Automatic Data Processing	4,150	4,265	4,606	1,155	1,326	4,954

This activity is accomplished by a support service contractor who performs programming, keypunch, data storage and listings for managerial, financial, and other administrative requirements.

The increase in 1976 and transition quarter from the budget estimates to the current estimates is due to support contractor wage escalation, the lease of an additional computer, and the purchase of an Ampex memory unit. It was more economical to purchase the memory rather than to continue leasing. The increase in 1977 is due to increased wage rates in the support contract for programming and operations, and the full year funding of the support contract, partially offset by a decrease in leased equipment costs stemming from the equipment purchase in 1976.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
B. Engineering Services.....	363	447	331	120	96	390

This activity includes engineering services for all minor construction projects. The change from the 1976 budget to the 1976 current estimate reflects a reduction of five manyears. In addition, an engineering study originally planned in the 1976 budget has been deferred until 1977. This, and increased wage rates, cause the 1977 increase.

C. Scientific and Technical Information and Educational Programs.....	1,621	1,995	1,749	881	1,064	2,004
1. Operation of technical library...	70	82	74	25	21	77

The technical library acquires approximately 14,000 books and periodicals a year. The decrease in 1976 from the budget estimate to the current estimate is due to a staffing reduction. The amount in 1977 reflects the same level of effort at a slightly higher wage rate.

2. Educational/Informational Programs.....	450	499	453	140	166	487

Included in this area are the unescorted tours of the Johnson Space Center by the general public. In FY 1975, approximately 800,000 visitors toured JSC. Also, included in this activity are the maintenance of exhibits; press conferences; news coverage of flights; distribution of exhibits; and film and press releases. These activities accounted for approximately 17,660 inquiries from news media and 1,138,731 publications furnished.

The change from the 1976 budget to current estimate reflects a reduction of one support contractor manyear, and a refinement of requirements. The funds for the Transition Quarter and 1977 provide for services at the 1976 level plus support contractor wage rate increases.

3. Scientific and Technical Information.....	1,101	1,414	1,222	716	877	1,440

The change from the 1976 budget to current estimate reflects a reduction of 12 manyears from the 1976 budget. The 1977 amount reflects a full year funding for these services at the current level of support.

ADMINISTRATIVE SUPPORT

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
V. ADMINISTRATIVE SUPPORT.....	7,272	7,482	7,112	2,563	1,959	7,293

Basis of Fund Requirements

Summary of Administrative Support

A. Communications						
1. Leased lines and tolls.....	819	865	867	234	225	772
2. Local telephone services.....	1,067	1,075	1,053	290	284	1,105
3. Other communications.....	107	117	120	32	33	127
Subtotal.....	1,993	2,057	2,040	556	542	2,004
B. Administrative Printing.....	632	525	600	142	146	600
C. Supplies, Materials, and Equipment..	1,600	1,134	1,204	306	370	1,300
D. Transportation						
1. Center operations.....	580	543	673	150	178	670
E. Administrative Support Services						
1. Installation support.....	1,659	2,108	1,641	1,104	488	1,720
2. Occupational medicine and environmental health.....	808	1,115	954	305	235	999
Subtotal.....	2,467	3,223	2,595	1,409	723	2,719
Total, Administrative Support.....	7,272	7,482	7,112	2,563	1,959	7,293

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)					
A. Communications	1,993	2,057	2,040	556	542	2,004

The small decrease in 1976 from the budget estimate to the current estimate is due to a refinement in the local exchange estimate. The further decrease in 1977 is due to a reduction in FTS utilization.

B. Administrative Printing	632	525	600	142	146	600

There were 53 million units of off-site printing in 1975. The 1976 current estimate reflects greater than planned printing for the ASTP windup. The funds for the Transition Quarter and 1977 provide for printing services relative to the buildup of Shuttle support.

C. Supplies, Materials, and Equipment	1,600	1,134	1,204	306	370	1,300

Approximately 124 thousand items are issued a year from stock. The funds for 1977 provide for services at the 1976 level and for the full year effect of cost increases.

D. Transportation	580	543	673	150	178	670

Transportation services are provided at JSC; WSTF; Bethpage, NY; and Downey, California. The increase from the 1976 budget estimate to the 1976 current estimate is due to engine overhaul on the administrative aircraft not reflected in the 1976 budget estimate. The 1977 costs are at the 1976 level.

E. Administrative Support Services	2,467	3,223	2,595	1,409	723	2,719

The major services in this category provide support of the installation generally. This includes equipment rental such as lease of 31 copiers that produce an average of 26,700,000 units annually; storage and issue functions handling approximately 130,000 units a year; forms and publications that necessitate the processing of approximately 600,000 items annually; moving and hauling; and support for the Center's activities at Ellington Air Force Base.

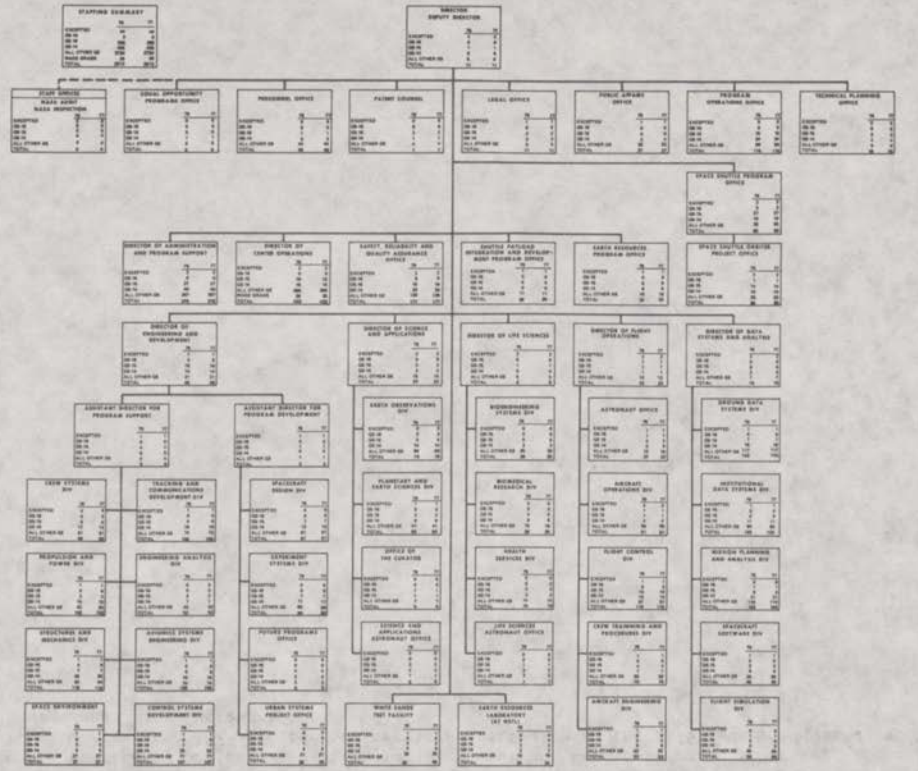
In addition, a contractor provides occupational medicine, industrial hygiene and environmental health services; operation of the dispensary for emergency medical treatment and employee physicals, handling approximately 22,000 patients a year; and recognition, measurement and control of hazardous working and environmental conditions.

The change from the 1976 budget to current estimate reflects a reduction of eight manyears and better identification of benefits by projects and programs for use of the cardiopulmonary laboratory. The funds for the Transition Quarter and 1977 provide for services continuing at the 1976 level, adjusted for the effect of 1976 wage and price increases.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LYNDON B. JOHNSON SPACE CENTER

HOUSTON, TEXAS



RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1977 ESTIMATES

JOHN F. KENNEDY SPACE CENTER

DESCRIPTION

Operations at the John F. Kennedy Space Center are conducted at two 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 139,305 acres. Breakdown of the acreage is as follows:

NASA-owned	82,943
Easement, Banana River Causeway	271
Easement, Indian River Causeway	296
Deed of Dedication, Florida-owned, submerged lands	55,795
Total	139,305

In addition, the Kennedy Space Center is resonsible 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 Vanderberg 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, 1975, was $1,293,177,000.

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 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 highly successful Apollo Soyuz Test Project was launched at KSC on July 15, 1975.

KSC is primarily involved in the design and development of launch, landing and vehicle refurbishment facilities and ground support equipment for the Space Shuttle. This activity includes modification to existing facilities and support equipment to the maximum extent possible, such as the Vehicle Assembly Building and launch pads, as well as design and construction of new facilities, such as the orbiter processing facility.

KSC, in addition to its responsibilities for the vehicle test, checkout, launch and refurbishment, is preparing to accommodate and support the various payloads to be flown on the space shuttle. These include such things as the Spacelab, being developed by the European Space Agency (ESA), the interim upper stage, and various scientific, communications and navigational satellites.

In the area of unmanned expendable vehicle launches, KSC launches from the Air Force Eastern Test Range at Cape Canaveral Air Force Station, Florida (located adjacent to KSC), and at the Air Force Western Test Range located on Vandenberg Air Force Base, California.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
I. Personnel and Related Costs.....	53,629	54,242	56,022	14,587	15,303	57,977
II. Travel.....	1,543	1,764	2,231	664	664	2,430
III. Facilities Services.....	25,460	24,488	23,084	8,961	8,961	25,264
IV. Technical Services.....	4,851	5,180	5,890	2,190	2,190	6,231
V. Administrative Support.....	10,435	9,300	10,184	3,351	3,351	11,722
Total, fund requirements.....	95,918	94,974	97,411	29,753	30,469	103,624

Distribution of Permanent Positions by Program

The following table summarizes the actual and planned utilitization of positions for direct program activity and for indirect support.

		1976		Transition Quarter		1977
Direct Positions	1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
			(Thousands of Dollars)			
Space Flight						
Space shuttle	522	1,223	1,240	1,223	1,240	1,256
Space flight operations	866	163	131	163	131	115
Expendable launch vehicles	274	292	284	292	284	284
Space Science						
Life sciences	2	3	3	3	3	3
Space Applications	34	40	40	40	40	40
Aeronautics and Space Technology						
Space research and technology	2	3	2	3	2	2
Subtotal, direct positions	1,700	1,724	1,700	1,724	1,700	1,700
Indirect Positions						
Director and staff	93	93	93	93	93	93
Administrative support	411	387	411	387	411	411
Research and development support	55	55	55	55	55	55
Subtotal, indirect positions	559	535	559	535	559	559
Total, permanent positions	2,259	2,259	2,259	2,259	2,259	2,259

PERSONNEL AND RELATED COSTS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
I. PERSONNEL AND RELATED COSTS.....	53,629	54,242	56,022	14,587	15,303	57,977
Basis of Fund Requirements						
A. Compensation and Benefits:						
1. Compensation						
a. Permanent positions.....	48,098	48,226	49,941	12,945	13,552	51,722
b. Nonpermanent.....	677	676	722	250	262	734
c. Reimbursable detailees.....	28	103	105	26	27	105
d. Overtime and other compensation	241	389	319	111	115	325
Subtotal, Compensation.....	49,044	49,394	51,087	13,332	13,956	52,886
2. Benefits.....	4,342	4,428	4,579	1,149	1,241	4,735
Subtotal, Compensation and Benefits.....	53,386	53,822	55,666	14,481	15,197	57,621
B. Supporting Costs:						
1. Transfer of personnel.....	53	70	70	18	18	70
2. Personnel training.....	190	350	286	88	88	286
Subtotal, Supporting Costs....	243	420	356	106	106	356
Total, Personnel and Related Costs.....	53,629	54,242	56,022	14,587	15,303	57,977

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
1. Compensation	49,044	49,394	51,087	13,332	13,956	52,886
a. Permanent positions	48,098	48,226	49,941	12,945	13,552	51,722

Basis of Cost for Permanent Positions

In 1977 the cost of permament positions will be $51,722, an increase of $1,781 from 1976. This increase is as follows:

Cost of permanent positions in 1976		49,941
Cost of increase in 1977		+2,631
Within grade advances and career development:		
Full year effect of 1976 and transition quarter actions	+507	
Partial year effect of 1977 actions	+591	
Change in number of reimbursable launches	+921	
Full year effect of October 1975 pay raise	+612	
Cost of decreases in 1977		-850
Turnover savings:		
Full year effect of 1976 and transition quarter actions	-238	
Partial year effect of 1977 actions	-418	
One less paid day in 1977	-194	
Cost of permanent positions in 1977		51,722

b. Nonpermanent						
Cost	$677	$676	$722	$250	$262	$734
Manyears	97	100	100	37	35	100

The 1977 plan includes 100 manyears. They will be used to support the following programs at approximately the levels indicated. The increase from the 1976 budget estimate and in 1977 are due to the October 1975 pay raise.

	Manyears
Cooperative training program	51
Summer program (Excluding disadvantaged youth)	8
Disadvantaged youth program	25
Other temporaries	16
Total	100

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
c. Reimbursable detailees	28	103	105	26	27	105

The 1977 estimate for military detailees includes funding for services of five engineers and one logistician, who will participate in shuttle development (i.e., maintainability and flight test support).

d. Overtime and other compensation	241	389	319	111	115	325

The most significant portion of the Center's overtime is in direct support of test, integration and checkout of launch vehicle systems and preparation of the vehicle for launch; and launch facility design, construction, maintenance and operation, including advanced planning and studies. The remaining portion of overtime and holiday pay is used for peak work loads, e.g., Source Evaluation Board and fiscal year-end closing. A reduction in the 1976 estimate represents a refinement of requirements after the ASTP launch. The increase in 1977 reflects the full year cost of the October 1975 pay raise.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Benefits	4,342	4,428	4,579	1,149	1,241	4,735

The increases in the 1976 current estimate and the 1977 estimate result primarily from the October 1975 pay raise and the increase in the government contribution to employee health and life insurance programs.

Category of Costs:

Contribution to the Civil Service Retirement Fund	3,397	3,497	3,530	940	960	3,649
Contribution for employee life insurance	192	192	201	49	51	208
Contribution to employee health insurance	728	714	823	154	224	853
Contribution to FICA	15	17	15	5	5	15
Incentive awards	10	8	10	1	1	10
Total	4,342	4,428	4,579	1,149	1,241	4,735
B. Supporting Costs	243	420	356	106	106	356
1. Transfer of personnel	53	70	70	18	18	70

The increase over the 1975 level is based on the anticipated number of moves and the higher average cost for the movement of household goods.

2. Personnel training	190	350	286	88	88	286

Personnel training costs are based on employee development programs which include supervision and management, technical and engineering updating, and administrative, communicative and clerical skills. Training costs also cover special mission orientation, i.e., flight and ground operations and facility build-up for Shuttle operations and the Affirmative Action Plan. The decrease in 1976 costs reflect a refinement of estimates based on current planning schedules.

TRAVEL

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
II. TRAVEL	1,543	1,764	2,231	664	664	2,430

Program related travel accounts for over 50% of the travel requirements at KSC. The travel function also includes transportation services provided by the GSA motor pool operation such as bus and taxi services and the rental of motor vehicles for all NASA elements and their contractors located in the area. The increase in 1976 over the budget estimate reflects the higher per diem rates effective in May 1975 and increased Shuttle activity. The increase in 1977 reflects continued growth in Space Transportation System activities at KSC related to the design and manufacturing of ground system equipment, design and construction of Shuttle facilities, the initial acceptance testing of Shuttle flight hardware and contractor supplied equipment, and the development testing of flight hardware manufactured at off-site locations.

Basis of Fund Requirements
Summary of Travel by Major Category

A. Program Travel	604	778	1,197	414	357	1,396
B. Meetings and Technical Seminars	9	46	24	19	8	24
C. Administrative Travel	930	940	1,010	231	299	1,010
Total, Travel	1,543	1,764	2,231	664	664	2,430

FACILITIES SERVICES

		1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
				(Thousands of Dollars)			
III.	FACILITIES SERVICES	25,460	24,488	23,084	8,961	8,961	25,264

Basis of Fund Requirements

Summary of Facilities Services

A.	Rental of Real Property	7	5	12	5	5	18
B.	Maintenance and Related Services						
	1. Maintenance, repair and alterations of buildings and grounds	10,073	8,970	7,806	3,518	3,518	8,604
	2. Custodial services	6,589	7,047	7,074	3,202	3,202	7,891
	3. Maintenance of equipment	834	404	749	136	136	753
	Subtotal	17,496	16,421	15,629	6,856	6,856	17,248
C.	Operation of Facilities						
	1. Utilities	4,734	5,365	5,365	1,379	1,379	5,736
	2. Supplies and equipment	3,223	2,697	2,078	721	721	2,262
	Subtotal	7,957	8,062	7,443	2,100	2,100	7,998
	Total, Facilities Services	25,460	24,488	23,084	8,961	8,961	25,264

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
A. Rental of Real Property.....	7	5	12	5	5	18

KSC provides temporary off-site news and guest centers for launch activity. The increase from the 1976 budget estimate reflects ASTP and Viking requirements previously planned to be fully obligated in 1975. The increase in 1977 is related to expanded activities for two Mariner/Jupiter/Saturn launches.

B. Maintenance and Related Services.....	17,496	16,421	15,629	6,856	6,856	17,248
1. Maintenance of buildings and grounds.....	10,073	8,970	7,806	3,518	3,518	8,604

This cateogry covers the cost of operating and maintaining the institutional facilities on Kennedy Space Center and NASA facilities on the Air Force Eastern Test Range, Cape Canaveral Air Force Station, Florida, and the Air Force Western Test Range, Vandenberg Air Force Base, 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. Three hundred thirteen (313) structural facilities contain 4.7 million square feet and require 26,000 tons of air conditioning; 13 heating plants, 212 linear miles of electrical lines and 150 unit substations; 24,000 linear feet of sewer lines, 26 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 about three times larger than the civil service population.

Operation and maintenance services are provided by a support contractor, about 90% of this category, and the balance represents minor contracts for one-time services. The decrease from the 1976 budget estimate reflects a reduction of 71 support contractor manyears. This manpower is level for 1977, with the increase due to contractor wage increases.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Custodial services.....	6,589	7,047	7,074	3,202	3,202	7,891

Services in this category include security at KSC and Cape Canaveral Air Force Station (CCAFS), fire protection at KSC, janitorial services for KSC and NASA facilities at CCAFS and Western Test Range, and minor contracts for refuse handling and laundry services. Security and fire protection services are provid·d by support contractors, with staffing required to meet security and safety standards in all areas, both institutional and operational. Janitorial services, also provided by a support contractor, are based on the 4.7 million square feet serviced.

The increase in 1976 from the budget estimate reflects support contract wage increases partially offset by a 50-manyear reduction. The increase in 1977 is due to contractor wage increases and higher costs for Eastern Test Range services partially offset by a 4-manyear reduction.

3. Maintenance of equipment.....	834	404	749	136	136	753

Funding requirements cover maintenance and repair of a wide variety of facility related heavy equipment, e.g., tractors, cranes, forklifts, trailers and pumps. Office copier service and maintenance and repair of a wide variety of office type equipment utilized by civil service and contractor personnel are also included. The increase in the 1976 current estimate reflects actual 1975 experience. The estimate for 1977 provides for an essentially level activity.

C. Operation of Facilities.....	7,957	8,062	7,443	2,100	2,100	7,998
1. Utilities.....	4,734	5,365	5,365	1,379	1,379	5,736

Funding requirements in this category cover the cost of electricity, water, heat/steam, and other utilities as appropriate at KSC and Western Test Range, including locally generated electricity at Cape Canaveral Air Force Station. Increase in 1977 is due to higher electricity rates.

2. Supplies and equipment.....	3,223	2,697	2,078	721	721	2,262

This category covers the cost of supplies, materials, and equipment used in the maintenance and operation of the facilities at KSC and Western Test Range. This includes those consumed by the support contractors in

performance of their maintenance/operations responsibilities. The decrease from the 1976 budget estimate reflects a revised estimate for ASTP support and a general reduction to allow reprogramming of funds to cover costs increases in other areas. The increase in 1977 is caused by the full year effect of price increases experienced during 1976.

TECHNICAL SERVICES

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars			
IV. TECHNICAL SERVICES	4,851	5,180	5,890	2,190	2,190	6,231

Basis of Fund Requirements

Summary of Technical Services

A. Automatic Data Processing						
1. Equipment	120	133	148	47	47	152
2. Programming and operation services	2,025	2,282	2,523	1,045	1,045	2,558
Subtotal	2,145	2,415	2,671	1,092	1,092	2,710
B. Scientific and Technical Information and Educational Programs						
1. Operation of NASA technical libraries	345	201	193	190	190	376
2. Educational/informational programs	145	94	267	30	30	134
3. Scientific and technical information	2,216	2,470	2,759	878	878	3,011
Subtotal	2,706	2,765	3,219	1,098	1,098	3,521
Total, Technical Services	4,851	5,180	5,890	2,190	2,190	6,231

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
A. Automatic Data Processing.....	2,145	2,415	2,671	1,092	1,092	2,710

This category provides for the lease and maintenance of general purpose data processing equipment, and programming and operation services for business-type applications, such as financial, personnel, security, and supply records. Increases in the 1976 current estimate and in 1977 reflect the lease of additional peripheral equipment for the Central Data System due to conversion from the IBM 360-50 to the Honeywell 635 planned for late 1976 and higher contractor wage rates, partially offset in 1977 by an 11 manyear reduction in effort.

B. Scientific and Technical Information and Educational Programs.....	2,706	2,765	3,219	1,098	1,098	3,521
1. Operation of NASA technical libraries.....	345	201	193	190	190	376

Funding requirement in this category covers the operation of the KSC library facility by a support contractor. The KSC library contains over 31,000 books and bound journals; 168,000 technical documents; 650,000 microfilm documents; and 185,000 specifications and standards. The increase in 1977 reflects the full year effect of contractor wages increases and a full twelve months funding on these contracts.

2. Educational/informational program..	145	94	267	30	30	134

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. Increase in the 1976 current estimate is primarily for restoration of exhibits for use during the Bicentennial. 1977 returns to the prior funding level following exhibit refurbishment in 1976.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
3. Scientific and technical information.....	2,216	2,470	2,759	878	878	3,011

Scientific and technical information services are provided to the total KSC population and include documentation, printing and reproduction, publication, photographic and translation services. This support includes the printing of test and checkout procedures, launch countdowns, microfilming, engineering drawings, telemetry data, and other related technical material. The increase in 1976 over the budget estimate reflects currently negotiated contractor wage rates which are above those anticipated in the 1976 budget, partially offset by a 5-manyear reduction in effort. The increase in 1977 reflects the full year effect of the contractor wage increases.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
V. ADMINISTRATIVE SUPPORT	10,435	9,300	10,184	3,351	3,351	11,722

Basis of Fund Requirements

Summary of Administrative Support

A. Communications						
1. Leased lines and long distance calls	699	757	768	165	165	664
2. Local telephone service	1,242	1,116	1,120	281	281	1,350
3. Other communications	102	94	98	30	30	94
Subtotal	2,043	1,967	1,986	476	476	2,108
B. Administrative Printing	174	292	214	116	116	220
C. Supplies, Materials and Equipment	1,295	823	1,070	238	238	1,299
D. Transportation						
1. Center operations	1,047	1,053	1,045	356	356	964
2. Common carrier	145	127	164	37	37	134
Subtotal	1,192	1,180	1,209	393	393	1,098
E. Administrative Support Services						
1. Installation support services	5,004	4,285	4,845	1,504	1,504	6,003

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Occupational medicine and environmental health.....	727	753	860	624	624	994
Subtotal.....	5,731	5,038	5,705	2,128	2,128	6,997
Total, Administrative Support.....	10,435	9,300	10,184	3,351	3,351	11,722
A. Communications.....	2,043	1,967	1,986	476	476	2,108

Funds support all NASA personnel, contractor and civil service, located on the Kennedy Space Center, the Eastern Test Range and the Western Test Range. It covers all communication services required to conduct official business within NASA, industry, and institutions located throughout the country. The cost of the local telephone service, Federal Telecommunications System (FTS), long distance tolls, and teletype services for the total complement are in this subcategory. The increase in 1976 from the budget estimate is due to rate increases approved in 1976, partially offset by savings resulting from a reduction in the number of telephone instruments. The increase in 1977 reflects the full year effect of the rate increases.

B. Administrative Printing.....	174	292	214	116	116	220

Estimates for administrative printing include funds for minor efforts such as the KSC house organ and miscellaneous special requirements for duplicating, photostating, blueprinting, microfilming, and other photographic reproductions. Services are performed by other government agencies or by commercial printing firms. The decrease in 1976 from the budget estimate reflects the completion of ASTP support requirements and a general reduction to allow reprogramming of funds to cover higher costs in other areas. Increase in 1977 is associated with KSC Shuttle efforts.

C. Supplies, Materials and Equipment.....	1,295	823	1,070	238	238	1,299

The requirements in this category cover a wide range of administrative supplies used by civil service and contractor personnel. This includes institutional equipment, such as furniture and office equipment, motor vehicle and transportation equipment, electronic equipment, and miscellaneous and noncapitalized equipment. Also included are rental of special-purpose business equipment, such as specialized typewriters, and printing equipment. The increase in the 1976 current estimate reflects actual 1975 experience. The increase in 1977 is the full year cost of higher prices experienced in 1976 and an increase in the total KSC population over the 1976 level.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
D. Transportation	1,192	1,180	1,209	393	393	1,098

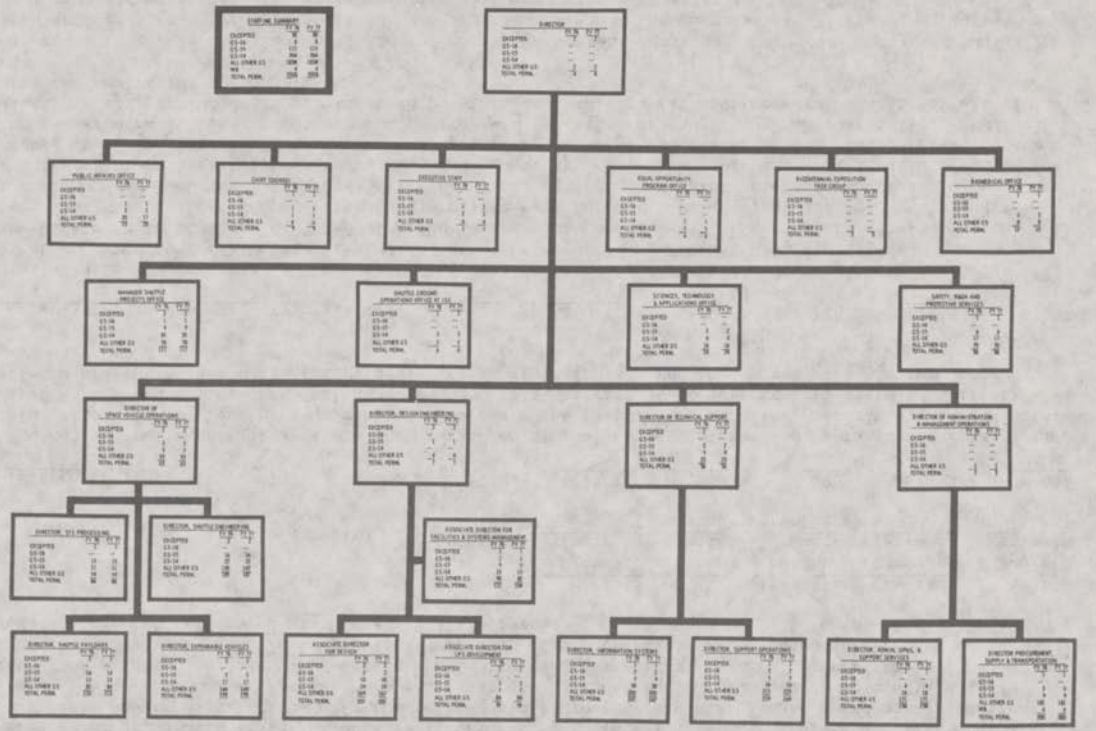
The major item in this category is the "cargo" motor pool operation provided by the General Services Administration (GSA). Funding requirements also cover the movement of supplies, materials, and equipment required by KSC and the Western Test Range by commercial carrier. The current 1976 estimate reflects 1975 experience and the higher cost of services. The decrease in 1977 reflects a reduction in the "cargo" motor pool.

E. Administrative Support Services	5,731	5,038	5,705	2,128	2,128	6,997

Installation support services are those support services not described elsewhere which have wide application throughout the Center, including logistics services at KSC and NASA facilities at the Cape Canaveral Air Force Station, mail and distribution services, and installation support services at the Western Test Range. Logistics services are provided by a support contractor at KSC and by the Eastern Test Range at Cape Canaveral Air Force Station. Services include receipt, storage, and issue of supplies and equipment as well as maintaining various management systems, such as repair, modification, and ordnance. Mail and distribution services are provided by a support contractor and include distribution of inter-office mail, classified document control and operation of the KSC branch post office. Medical services are also included and provide both occupational medicine and environmental health for all civil service and contractor personnel.

Increase in the 1976 current estimate reflects a 16-manyear increase in support contractor effort to provide logistics services associated with Shuttle buildup. The increase in 1977 provides for support contract wage increases and an additional 20 contractor manyears to fully implement the logistics activity.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
JOHN F. KENNEDY SPACE CENTER



RPM 2-18

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1977 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, 1975, was $428,801,000. Certain facilities such as the Redstone Arsenal Air Field 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, where the External Tank for the Space Shuttle is being produced along with other MSFC activities and where activities for other Federal agencies are conducted. The Michoud Facility occupies 891 acres and provides 3,570,097 square feet of building 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, 1975, was $146,276,000.

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, 1975, was $28,528,000.

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, 1975, was $815,412,000.

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 spacecraft and selected scientific payloads, and other systems for present and future space exploration.

The Center is currently involved in the direction and management of the following activities:

1. Space Shuttle Projects:

a. Space Shuttle Main Engine - the high performance, reusable, throttleable liquid hydrogen, liquid oxygen fueled rocket engine for the orbiter vehicle.

b. External Tank - the expendable carrier providing the liquid hydrogen/liquid oxygen propellant for the orbiter vehicle during lift-off through orbital insertion.

c. Solid Rocket Booster - the twin solid propellant boosters, which fire in parallel with the main engine and are designed for retrieval, refurbishment and reuse.

d. Testing - system and project tests of the main propulsion system, conducting mated vertical ground vibration testing, and structural testing of the solid rocket booster and external tank, utilizing modified existing facilities at MSFC and the National Space Technology Laboratories.

e. Integration - systems analysis activities and system assessments in support of Shuttle lead center and MSFC Shuttle projects.

2. The High Energy Astronomy Observatory - Technical and program management of an orbital spacecraft and payload designed to obtain high quality, high resolution data on cosmic ray, gamma ray, and X-ray sources.

3. Spacelab - Marshall is the manager of the elements of the system which are NASA's responsibility (i.e., crew transfer tunnel, hardware mock-ups, crew trainers, etc.); and is the NASA interface with the European Space Agency, the developer of the main modules.

4. Interim Upper Stage (IUS) - Marshall is the manager for the design and development of unique items to support all non-DOD mission planning and implementation for the IUS, which is being developed by DOD and will be used to deploy Shuttle-launched payloads to high energy orbits. Marshall is responsible for assuring that the IUS meets the integration and operational requirements for NASA and other non-DOD missions.

The Center has also been assigned the lead role in the study and definition of several potential future programs, including:

a. The Space Telescope, a Shuttle-launched, optical telescope to provide for international scientific use, and significantly extend knowledge of the universe.

b. The Atmospheric Cloud Physics Laboratory (ACPL) which will be utilized to further the basic understanding of atmospheric cloud microphysical processes and phenomena, thereby contributing to improved weather predictions.

c. Space Processing studies, aimed at structuring a research program, as an extension of the space processing experiments conducted on board the Apollo, Skylab, and ASTP missions, to investigate the effects of low gravity and other space flight phenomena upon processes and materials of national concern. Near term activities utilize sounding rocket payloads to define systems and processes for further development for Shuttle/Spacelab missions.

In addition, Marshall has a significant role in the near term systems development of a Solar Heating and Cooling Demonstration program in support of the Energy Research and Development Administration.

Marshall is also participating in NASA Earth Resources Survey regional program activities as directed generally toward the application of space technology and associated managerial and technical disciplines to solve environmental problems in the geographic region including Alabama, Tenessee, Kentucky, Missouri, Louisiana, Mississippi, Georgia, and North Carolina.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
I. Personnel and Related Costs.....	105,469	105,900	107,735	27,150	28,315	106,273
II. Travel.....	1,926	2,115	2,205	556	582	1,905
III. Facilities Services.....	9,623	9,601	10,949	3,143	3,373	12,116
IV. Technical Services.....	6,389	6,919	6,724	1,870	1,732	6,876
V. Administrative Support.....	5,643	5,971	5,829	1,653	1,660	5,995
Total, fund requirements.....	129,050	130,506	133,442	34,372	35,662	133,165

Permanent Positions by Program

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Direct Positions						
Space Flight						
Space shuttle	1,323	1,523	1,514	1,523	1,514	1,538
Space flight operations	1,173	1,095	1,029	1,095	1,029	918
Expendable launch vehicles	15	60	6	60	6	---
Space Science						
Physics and astronomy	428	398	418	398	418	354
Life sciences	30	21	---	21	---	---
Applications						
Space applications	143	114	149	114	149	164
Aeronautics and Space Technology						
Aeronautical research and technology	13	13	11	13	11	11
Space research and technology	158	80	173	80	173	225
Technology Utilization	9	10	10	10	10	12
Subtotal, direct positions	3,292	3,314	3,310	3,314	3,310	3,222
Indirect Positions						
Director and Staff	136	139	144	139	144	130
Administrative support	633	621	621	621	621	539
Research and development support	52	39	38	39	38	34
Subtotal, indirect positions	821	799	803	799	803	703
Total, permanent positions	4,113	4,113	4,113	4,113	4,113	3,925

PERSONNEL AND RELATED COSTS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
I. PERSONNEL AND RELATED COSTS.....	105,469	105,900	107,735	27,150	28,315	106,273
Basis of Fund Requirements						
A. Compensation and Benefits						
1. Compensation						
a. Permanent positions.....	93,675	94,642	95,859	24,137	25,025	94,613
b. Nonpermanent.....	1,529	1,641	1,675	608	624	1,701
c. Reimbursable details.....	22	69	67	18	20	68
d. Overtime and other compensation.....	551	606	627	151	170	636
Subtotal, compensation.....	95,777	96,958	98,228	24,914	25,839	97,018
2. Benefits.....	9,273	8,538	9,084	2,135	2,363	8,832
Subtotal, compensation and benefits.....	105,050	105,496	107,312	27,049	28,202	105,850
B. Supporting Costs						
1. Transfer of personnel.....	111	120	101	30	32	101
2. Personnel training.....	308	284	322	71	81	322
Subtotal, supporting costs.....	419	404	423	101	113	423
Total, personnel and related costs.....	105,469	105,900	107,735	27,150	28,315	106,273

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
1. Compensation	95,777	96,958	98,228	24,914	25,839	97,018
a. Permanent positions	93,675	94,642	95,859	24,137	25,025	94,613

The increase from the 1976 budget estimate to the 1976 current estimate, and from the budgeted Transition Quarter to the current Transition Quarter, is due to the October 1975 pay raise. The decrease in 1977 is attributable to an MSFC civil service reduction and an increase in reimbursable activity. These two factors combine to more than offset the full year effect of the October 1975 pay raise.

Basis of Cost for Permanent Positions

In 1977 the cost of permanent positions will be 94,613. This decrease results from the following:

Cost of permanent positions in 1976		95,859
Cost increases in 1977		+3,053
Within grade advances and career development:		
Full year effect of 1976 and transition quarter actions	+1,092	
Partial year effect of 1977 actions	+602	
Full year effect of October 1975 pay raise	+1,359	
Cost decreases in 1977		-4,299
Turnover savings:		
Full year effect of 1976 and transition quarter actions	-390	
Partial year effect of 1977 actions	-337	
Partial year effect of 1977 manpower reductions	-1,834	
Increase in reimbursable activity	-1,370	
One less paid day in 1977	-368	
Cost of permanent positions in 1977		94,613

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	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
b. Nonpermanent						
1. Cost	$1,529	$1,641	$1,675	$608	$624	$1,701
2. Manyears	226	250	250	92	96	250

The 1977 plan includes 250 manyears which will be used to support the following programs at approximately the levels included:

Program	Manyears
College cooperative training	107
Vocational cooperative training	25
Summer employment	28
Youth opportunity	69
Other temporary employment	21
Total	250

The 1976 current estimate is increased from the 1976 budget due to the October 1975 pay raise, which is also the cause of the increase in 1977.

c. Reimbursable details	22	69	67	18	20	68

Reimbursable details 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 decrease from the 1976 budget estimate to the current estimate is due to a slight schedule change in bringing one of the detailees onboard. This results in a less than three full manyears of effort, as originally planned. The 1977 effort is at the same level as in 1976.

d. Overtime and other compensation	551	606	627	151	170	636

The increases in 1976 and in the Transition Quarter are due to the October 1975 pay raise. The current estimate for 1977 is at same level as in 1976 with a cost increase due to the full year effect of the pay raise. Emphasis is placed on holding overtime costs to the lowest possible level consistent with mission and statutory requirements.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Benefits	9,273	8,538	9,084	2,135	2,363	8,832
The distribution of these costs by major categories is as follows:						
Category of Cost						
Contribution to the Civil Service retirement fund	6,588	6,694	6,743	1,718	1,738	6,701
Contribution for employee life insurance	374	361	428	91	102	430
Contribution for employee health insurance	1,471	1,196	1,576	300	482	1,583
Contribution to FICA	28	25	34	5	20	34
Incentive awards	84	84	84	21	21	84
Severance pay	728	178	219	---	---	---
Total	9,273	8,538	9,084	2,135	2,363	8,832

The increase from the 1976 budget estimate to the 1976 current estimate is due to the October 1975 pay raise, and the increase in the Government's contribution to employee life insurance and employee health insurance.

The lower estimate in 1977 from the 1976 estimate is mainly due to the phase-out of severance pay in 1976 resulting from the RIF in 1975, and also the lower personnel ceiling in 1977.

B. Supporting Costs	419	404	423	101	113	423
1. Transfer of personnel	111	120	101	30	32	101

The estimated costs (based on the number and the historical average cost of relocations) provide for certain relocation costs, such as real estate expenses and the movement of household goods. The actual number of moves in 1975 was 34. The 1976 and 1977 estimate is based on 28 moves.

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	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)					
2. Personnel training.....	308	284	322	71	81	322

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 to equip employees to advance to more responsible positions and to provide the Center with highly motivated and experienced personnel. As a result of the 1975 reduction in force at MSFC, it was necessary to provide training for employees as they moved to new jobs and responsibilities. The increase in 1976 from the budget estimate to the current estimate is the result of these actions. The 1977 estimate recognizes a continuing need for this training.

TRAVEL

II. TRAVEL.....	1,926	2,115	2,205	556	582	1,905

Approximately 88 percent of the total MSFC travel estimate is program related travel. Travel requirements include those for on-going programs such as Space Shuttle Main Engine, External Tank and Solid Rocket Booster, Spacelab, IUS/Tug, HEAO, and Laser Geodynamic Satellite as well as programs in the definition stage such as Space Telescope, Zero-G, Cloud Physics and other space science and applications payloads.

The increase from the 1976 budget estimate to the 1976 current estimate is due to the per diem rate increase, partially offset by a reduction in program related travel. This was accomplished by carefully reexamining each requirement, plus an increase in the use of teleconferencing. The decrease in 1977 reflects the full year effect of the travel reduction program implemented in 1976.

Basis of Fund Requirements

Summary of Travel by Major Category

A. Program Travel.....	1,690	1,962	1,964	495	515	1,667
B. Meetings and Technical Seminars.....	29	12	30	4	10	30
C. Administrative Travel.....	207	141	211	57	57	208
Total.....	1,926	2,115	2,205	556	582	1,905

FACILITIES SERVICES

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
III. FACILITIES SERVICES.....	9,623	9,601	10,949	3,143	3,373	12,116

Basis of Fund Requirements

Summary of Facilities Services

A. Maintenance and Related Services						
1. Maintenance, repair and alteration of buildings and grounds.....	1,347	2,055	1,763	562	1,007	2,037
2. Custodial services.....	2,488	2,343	2,490	725	658	2,590
3. Maintenance of equipment.....	521	564	577	158	225	588
Subtotal.....	4,356	4,962	4,830	1,445	1,890	5,215
B. Operation of Facilities						
1. Utilities.....	4,419	4,013	5,510	1,446	1,328	6,170
2. Supplies and equipment.....	848	626	609	252	155	731
Subtotal.....	5,267	4,639	6,119	1,698	1,483	6,901
Total, facilities services.....	9,623	9,601	10,949	3,143	3,373	12,116
A. Maintenance and Related Services.....	4,356	4,962	4,830	1,445	1,890	5,215
1. Maintenance, repair and alterations of buildings and grounds.....	1,347	2,055	1,763	562	1,007	2,037

These services are performed by the U.S. Army Missile Command (AMC) on a reimbursable basis and by 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. A major portion of the maintenance of buildings and grounds is performed by the Center's support contractor who maintains a miscellaneous crafts capability composed of building and construction trades.

The change from the 1976 budget to the current estimate for 1976 reflects a reduction of 14 manyears, as well as the deferral of some maintenance projects into the transition quarter. The increase from the budget to the current estimate for the transition quarter is due to support contractor wage increases and the maintenance projects deferred from 1976. The 1977 estimate reflects a further reduction of support contractor effort offset by wage and price escalation.

The change from the 1976 budget to the current estimate reflects a reduction of 14 manyears, as well as the deferral of some maintenance projects into 1977. The 1977 estimate reflects a further reduction of support contractor effort offset by wage and price escalation and the maintenance projects deferred from 1976.

	1975	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
	(Thousands of Dollars)					
2. Custodial services.....	2,488	2,343	2,490	725	658	2,590

Custodial services are performed principally by support service contractor personnel and include janitorial services for 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, movement and disposal of refuse 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 increase in 1976 from the budget estimate to the current estimate is due to the recompetition of the support contract covering security services. The 1977 amount reflects a full year's funding for these services and the full year effect of support contractor wage increases partially offset by a reduction of 33 manyears of janitorial effort.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
3. Maintenance of equipment.....	521	564	577	158	225	588

This line item provides for maintenance and repair of instrument, office and shop equipment by several small contractors and includes such items as microscopes, adding machines, calculators, typewriters, lathes, and crimping and milling machines.

The estimate in 1977 provides for the same continuing level of services.

B. Operation of Facilities.....	5,267	4,639	6,119	1,698	1,483	6,901
1. Utilities.....	4,419	4,013	5,510	1,446	1,328	6,170

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 are metered to the Center and sewage cost is pro-rated based on on-post population (per capita). The increase in 1976 from the budget to the current estimate is due to rate escalation in electricity of 27.7 percent; steam 40.2 percent; and sewage rates 25 percent. The increase in 1977 is due to the full year effect of the rate increases with consumption remaining at the 1976 level.

2. Supplies and equipment.....	848	626	609	252	155	731

This line item includes building materials (chemical, electrical, electronic, maintenance, hardware); instrumentation, metals, pipes, valves and fittings plus mechanical equipment and shop machinery. The current estimate for 1976 reflects deferral of purchases to provide funds to cover the unexpected utility rate increases. The 1977 estimate provides for a full year's purchase of supplies and equipment.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
IV. TECHNICAL SERVICES.....	6,389	6,919	6,724	1,870	1,732	6,876

Basis of Fund Requirements

Summary of Technical Services

A. Automatic Data Processing						
1. Equipment.....	409	338	492	85	122	526
2. Programming and operations.....	3,898	4,330	3,904	1,163	965	4,039
Subtotal.....	4,307	4,668	4,396	1,248	1,087	4,565
B. Engineering Services.....	106	188	281	47	73	281
C. Scientific and Technical Information and Educational Programs						
1. Operation of Redstone Scientific and Information Center.....	818	901	768	224	283	875
2. Educational/Informational Programs.....	105	691	109	206	34	100
3. Scientific and Technical Information.....	1,053	471	1,170	145	255	1,055
Subtotal.....	1,976	2,063	2,047	575	572	2,030
Total, technical services.....	6,389	6,919	6,724	1,870	1,732	6,876

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)					
A. Automatic Data Processing.....	4,307	4,668	4,396	1,248	1,087	4,565

This line item includes the cost of the support service contract for ADP operations, programming, and systems design. Also included are the costs of lease, maintenance and repair of ADP equipment. The decrease from the 1976 budget to the current 1976 estimate reflects a reduction of 22 manyears in programming and operation services. The 1977 amount reflects a further reduction of four manyears offset by the full year effect of support contractor wage increases.

B. Engineering Services.....	106	188	281	47	73	281

This line item provides for engineering design service, master planning and facility utilization studies. The increase from the 1976 budget to the current estimate reflects an increase in the scope of these studies in 1976 and 1977.

C. Scientific and Technical Information and Educational Programs.....	1,976	2,063	2,047	575	572	2,030
1. Operation of Redstone Scientific and Information Center.....	818	901	768	224	283	875

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 over 1,000,000 documents on microfilm. The change from the 1976 budget to the current estimate is due to an updated estimate submitted by the Army to MSFC. The 1977 estimate reflects the normal level of services.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Educational/Informational Programs	105	691	109	206	34	100

The decrease from the budget to the current estimate in both 1976 and the Transition Quarter is due to a recategorization of technical documentation and graphics into Scientific and Technical Information from Educational/Informational Programs. In addition, there is a reduction of two manyears from the 1976 budget to the current estimate. The decrease in 1977 reflects a further decrease in support contractor effort.

3. Scientific and Technical Information	1,053	471	1,170	145	255	1,055

This subfunction includes graphics, models work, chart, and related art work, motion picture services, photo materials for Scientific and Technical Information Programs. The increase from the budget estimate in both 1976 and the Transition Quarter is due to the recategorization explained above. There is also a reduction of six support contractor manyears. The decrease in 1977 is due to a further reduction of 14 manyears in the support contractor effort.

ADMINISTRATIVE SUPPORT

V. ADMINISTRATIVE SUPPORT	5,643	5,971	5,829	1,653	1,660	5,995

Basis of Fund Requirements

Summary of Administrative Support

A. Communications						
1. Leased lines and long distance tolls	664	602	863	162	225	624
2. Local telephone service	732	775	820	193	205	862
3. Other communications	163	128	125	35	31	91
Subtotal	1,559	1,505	1,808	390	461	1,577

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
B. Administrative Printing	330	340	302	85	124	352
C. Supplies, Materials and Equipment	1,441	1,033	1,006	366	332	1,311
D. Transportation						
1. Center operations	1,024	1,448	1,136	385	320	1,138
2. Common carrier	26	35	65	9	21	65
Subtotal	1,050	1,483	1,201	394	341	1,203
E. Administrative Support Services						
1. Installation support services	851	1,194	1,050	318	275	1,041
2. Occupational medicine and environmental health	412	416	462	100	127	511
Subtotal	1,263	1,610	1,512	418	402	1,552
Total, administrative support	5,643	5,971	5,829	1,653	1,660	5,995
A. Communications	1,559	1,505	1,808	390	461	1,577

This subfunction provides for leased lines and long distance tolls, local phone and exchange services, message services, minor communication projects and radio services.

The increase from the budget to the current estimate in both 1976 and the Transition Quarter is due to the addition of the funding of the Telecommunication Pilot Project. The decrease in 1977 reflects the completion in 1976 of the non-recurring procurement and installation of the Telecommunication Pilot Project, which has helped to reduce travel costs.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
B. Administrative Printing.....	330	340	302	85	124	352

This subfunction provides for administrative printing and reproduction of instructions, directives, budgetary and programmatic data, requests for quotations, procurement and contracting documents, Public Affairs material, etc. This service is obtained through Government printing facilities as well as commercial sources.

The decrease in 1976 from the budget to the current estimate is due to a rephasing of printing requirements into the Transition Quarter. The 1977 amount reflects the normal level of services.

C. Supplies, Materials and Equipment....	1,441	1,033	1,006	366	332	1,311

This subfunction provides for such items of administrative supplies as fuels and lubricants, general operating and service materials, miscellaneous air conditioning and utility supplies, office supplies, furniture, and general purpose equipment such as photographic, electrical, and office equipment.

Procurement of supplies, materials and equipment was constrained in 1976 in order to provide for unexpected cost increases, particularly utility rates. The 1977 estimate provides for a full year's purchase of supplies, materials and equipment at current prices.

D. Transportation.....	1,050	1,483	1,201	394	341	1,203

This subfunction encompasses the maintenance and storage of vehicles, aircraft operation and services, transportation of things, local movements, operation of the motor pools, and maintenance and repair of mobile equipment.

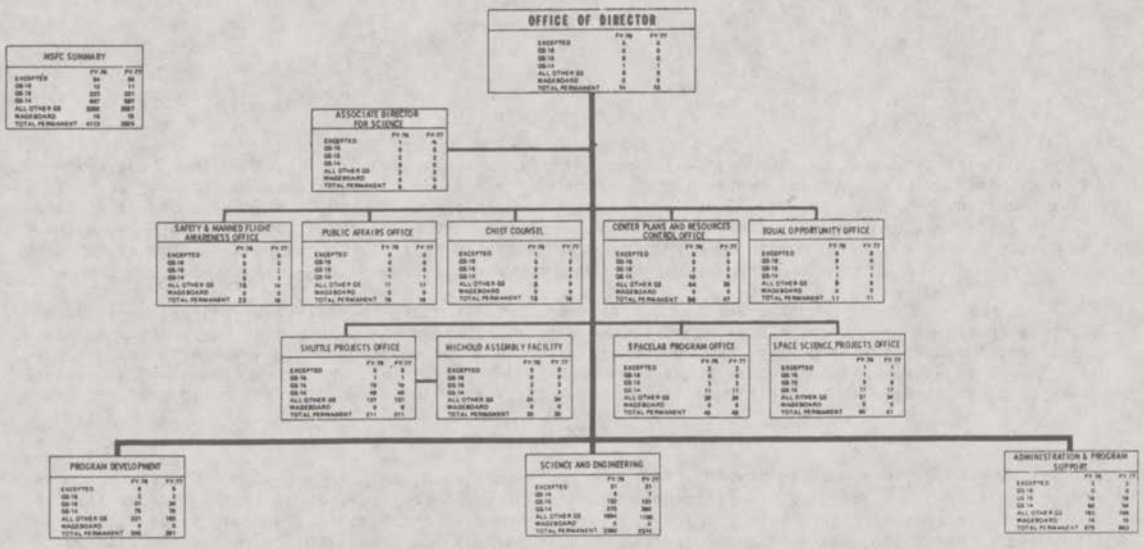
The change from the 1976 budget to current estimate reflects the minimum obligation required in 1976 in order to provide funds for increased costs in other functions above that originally anticipated in the 1976 budget. The 1977 amount reflects a full year's funding for these services, offset by a reduction of 20 manyears from 1976.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
E. Administrative Support Services.....	1,263	1,610	1,512	418	402	1,552

This line item provides for rental of equipment such as copiers; technical publications and logistics support; telecommunitations; TV productions and distribution; occupational and industrial health; tort claims; miscellaneous services performed by the Army Missile Command; and the maintenance and repair of photo and reproduction equipment.

The decrease in 1976 from the budget to the current estimate reflects a reduction of five support contractor manyears from the 1976 budget. In 1977, the full year effect of increased wage rates more than offsets a further reduction of five manyears in contractor support services.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER



RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1977 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 20,642 are NASA-owned and 118,165 acres are under restrictive easements. Within the total area, 125,327 acres are utilized as a buffer zone. Capital investment for the National Space Technology Laboratories as of June 30, 1975, was approximately $320,021,000. The installation has deep water 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 is 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, Department of Commerce, Environmental Protection Agency, Department of Transportation, Department of Defense, State of Mississippi, State of Louisiana, and the Earth Resources Laboratory, collocated from the Johnson Space Center.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
I. Personnel and Related Costs.....	1,598	1,672	1,736	418	434	1,802
II. Travel.....	25	24	31	5	8	31
Total, fund requirements.....	1,623	1,696	1,767	423	442	1,833

Distribution of Positions by Program

The following table summarizes the actual and planned utilization of positions at the National Space Technology Laboratories:

Indirect Positions

Director and staff.....	4	4	4	4	4	4
Administrative support.....	42	42	42	42	42	42
Research and development support.....	24	24	24	24	24	24
Total, permanent positions.....	70	70	70	70	70	70

PERSONNEL AND RELATED COSTS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
I. PERSONNEL AND RELATED COSTS.....	1,598	1,672	1,736	418	434	1,802
Basis of Fund Requirements						
A. Compensation and Benefits						
1. Compensation						
a. Permanent positions.....	1,443	1,514	1,557	378	392	1,619
b. Nonpermanent.....	18	16	20	4	5	20
c. Overtime and other compensation.....	6	6	7	2	2	7
Subtotal, Compensation....	1,467	1,536	1,584	384	399	1,646
2. Benefits.....	131	136	147	34	35	151
Subtotal, Compensation and Benefits.....	1,598	1,672	1,731	418	434	1,797
B. Supporting Costs						
1. Personnel training.....	---	---	5	---	---	5
Subtotal, Supporting Costs	---	---	5	---	---	5
Total, Personnel and Related Costs...	1,598	1,672	1,736	418	434	1,802

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
1. Compensation	1,467	1,536	1,584	384	399	1,646
a. Permanent positions.....	1,443	1,514	1,557	378	392	1,619

The current estimate for 1976 increased from the 1976 budget estimate due to the October 1975 pay raise. The transition quarter is a run-out at the 1976 level. The increase in 1977 reflects within grade advances and career development, and the full year cost of the October 1975 pay raise.

Basis of Cost for Permanent Positions

In 1977 the cost of permanent positions will be $1,619, an increase of $62 from 1976. The increase is calculated as follows:

Cost of permanent positions in 1976.....		1,557
Cost increases in 1977.....		+81
Within grade advances and career development		
Full year effect of 1976 and Transition Quarter actions.....	+47	
Partial year effect of 1977 actions.....	+16	
Full year effect of October 1975 pay raise.....	+18	
Cost decreases in 1977.....		-19
Turnover savings		
Full year effect of 1976 and Transition Quarter actions.....	-14	
One less paid day in 1977.....	-5	
Cost of Permanent positions in 1977.....		1,619

b. Nonpermanent

Cost.....	$18	$16	$20	$4	$5	$20
Manyears.....	2	2	2	1	1	2

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			

The increase from the 1976 budget estimate to the 1976 current estimate is due to the October 1975 pay raise.

c. Overtime and other compensation..	6	6	7	2	2	7

The 1976 and 1977 funds cover the overtime necessary to meet management and other administrative requirements in such areas as procurement and financial management. The slight increase in 1976 is due to the October 1975 pay raise.

2. Benefits.....	131	136	147	34	35	151

The following table indicates the personnel benefits costs by major category:

Category of Cost						
Contribution to Civil Service Retirement.....	104	107	111	27	27	115
Contribution for Employee Life Insurance.....	6	6	7	2	2	7
Contribution for Employee Health Insurance.....	21	22	25	5	6	28
Incentive Awards.....	--	1	4	--	--	1
Total.....	131	136	147	34	35	151

The current estimate for 1976 increased from the 1976 budget estimate as a result of the October 1975 pay raise, and the increase in the government's contribution to employee health insurance and employee life insurance. The increase in 1977 reflects the full year cost of the pay raise.

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	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
3. Supporting Cost.....	---	---	5	---	---	5
a. Personnel training.....	---	---	5	---	---	5

When NSTL was a part of the Marshall Space Flight Center, training was provided by MSFC. Beginning with the 1976 current estimate, NSTL is establishing their own training program. The personnel training costs are based on the urgent need for "Upward Mobility" training for women and other minorities and EEO "Counselor Training."

TRAVEL

II. TRAVEL.....	25	24	31	5	8	31

Travel requirements are associated with the operation and maintenance of the facility, committee assignments, management meetings, program support to the Office of Applications, and administrative matters such as legal, contracting, finance, and resources management.

The current estimate for 1976 is increased from the 1976 budget estimate due to an additional Applications's research project and increased per diem rates.

Basis of Fund Requirements

Summary of Travel by Major Category

A. Program related travel.....	---	---	4	---	1	4
B. Administrative travel.....	25	24	27	5	7	27
Total, Travel.....	25	24	31	5	8	31

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NATIONAL SPACE TECHNOLOGY LABORATORIES

NSTL SUMMARY

	FY 75	FY 76
EXCEPTED	1	1
GS-16	1	1
GS-15	1	2
GS-14	9	9
ALL OTHER GS	58	57
TOTAL PERMANENT	70	70

OFFICE OF THE MANAGER

	FY 75	FY 76
EXCEPTED	1	1
GS-15	1	1
ALL OTHER GS	3	3
TOTAL PERMANENT	5	5

RESOURCES & FINANCIAL MANAGEMENT OFFICE

	FY 75	FY 76
GS-14	1	1
ALL OTHER GS	17	16
TOTAL PERMANENT	18	17

PROCUREMENT & CONTRACTS OFFICE

	FY 75	FY 76
GS-14	1	1
ALL OTHER GS	11	11
TOTAL PERMANENT	12	12

PUBLIC AFFAIRS OFFICE

	FY 75	FY 76
GS-13	1	1
ALL OTHER GS	-	-
TOTAL PERMANENT	1	1

GENERAL COUNSEL

	FY 75	FY 76
GS-14	1	1
ALL OTHER GS	1/2	1/2
TOTAL PERMANENT		

OFFICE OF INSTALLATION OPERATIONS

	FY 75	FY 76
GS-15	-	1
GS-14	3	3
ALL OTHER GS	14	14
TOTAL PERMANENT	17	18

OFFICE OF APPLICATIONS ENGINEERING

	FY 75	FY 76
GS-16*	1	1
GS-14	3	3
ALL OTHER GS	11	11
TOTAL PERMANENT	15	15

* DEPUTY NSTL MANAGER

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1977 ESTIMATES

GODDARD SPACE FLIGHT CENTER

DESCRIPTION

The Goddard Space Flight Center, located 15 miles northeast of Washington, D.C., at Greenbelt, Marvland, 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 contractor-held facilities at various locations as of June 30, 1975, was $716,150,000.

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.

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 in space science and applications. The Goddard Center has developed many diverse capabilities: the management of complex projects; the development of wholly integrated spacecraft, ranging from systems engineering to development, integration, and testing; the development and operation of satellite tracking networks, data acquisition and analysis; and scientific research to include both theoretical studies and the development of many significant scientific experiments flown in satellites.

Goddard is responsible for the development of sounding rockets and automated earth orbital spacecraft, including experiment integration. This currently includes applications satellite projects such as the Earth Resources Technology Satellite (LANDSAT-C), the Air Pollution Observing Satellite (NIMBUS-G), the Operational Temperature Sounding Satellite (TIROS-N), the Applications Explorer Missions (AEM), and the proposed Thematic Mapper. This also includes scientific satellite projects such as the proposed Solar Maximum Mission (SMM), and the small Explorer series. Goddard is also responsible for maintaining a technical discipline base as well as developing and managing experiments in the areas of space physics, space astronomy, stratospheric research, weather and climate, earth and ocean dynamics, communications,

and in aspects of planetary science, pollution monitoring, and earth resources. Goddard is responsible for flight command and control of automated earth orbital spacecraft as well as tracking and data acquisition for automated earth orbital flights, and the earth orbital phase of deep space flights. This includes management and operation of the world-wide Spacecraft Tracking and Data Network (STDN) and NASA Communications Network (NASCOM), and acquisition of Tracking and Data Acquisition Relay Satellite System services. Goddard is also responsible for the development and procurement of launch systems, including sounding rockets and the Delta launch vehicle.

Major Goddard activities during 1975 were in the following areas:

Applications Satellites - Goddard was heavily involved with several key applications satellite projects. The Synchronous Meteorological Satellite (SMS-2) launched in February 1975 provides continuous weather coverage from a geostationary orbit on an operational basis. The Earth Resources Technology Satellite (LANDSAT-2) launched in January 1975, provides high quality imagery of the earth and aids in a wide variety of earth resource disciplines. LANDSAT-C, scheduled for launch in late 1977, will provide a capability to experiment with improved remote sensors. The All-Weather Atmospheric Sounding Experiment Satellite (NIMBUS-6), launched in June 1975, provides data on a global basis for more accurate long term weather forecasts. NIMBUS-G is a continuation of the Nimbus satellite program with emphasis on air pollution and oceanographic observations, scheduled for launch in 1978. TIROS-N will provide improved measurements of the earth's surface and its atmosphere for meteorological monitoring purposes, also scheduled for launch in 1978. The Heat Capacity Mapping Mission (HCMM), the first of the Applications Explorers, is scheduled for a 1978 launch. Goddard Space Flight Center is also involved in the management of reimbursable projects such as Geostationary Operational Environmental Satellite (GOES) and Improved Tiros Operational Satellite (ITOS) which are funded by the National Oceanic and Atmospheric Administration.

Scientific Satellites - Goddard-managed scientific satellites are continuing to probe the complex nature of our solar system and the universe. OSO-8, launched in June 1975, provides for a systematic study of the Sun that will greatly improve our understanding of the very large temperature difference between the outer atmosphere of the Sun and the lower atmosphere. Explorer 53, launched in May 1975, is a small astronomy satellite that surveys the celestial sphere and searches for sources radiating in the X-ray, gamma ray, ultraviolet and other spectral regions both inside and outside our galaxy. Explorers 54 and 55, launched late in 1975, are scientific satellites designed to investigate the chemical process and energy transfer mechanisms which control the Earth's atmosphere. International Ultraviolet Explorer (IUE), to be launched in 1977, will be used by both the United States and foreign experimentors to study the spectra of the stars. International Sun Earth Explorer (ISEE), to be launched in 1977-78, will use three satellites (2 NASA, 1 ESRO) to conduct plasma and particle studies of the Earth's magnetosphere.

International Program - Goddard continues in its responsibility to carry out international cooperative efforts in space exploration. HELIOS-B, to be launched in early 1976, is a German-built satellite containing three Goddard experiments which will investigate the properties of the processes in interplanetary space close to the Sun.

Tracking and Data Acquisition. The Goddard-managed Spaceflight Tracking and Data Network (STDN) provides tracking and communications coverage for all of NASA's satellites through lunar distances. The STDN provided the tracking support for the Apollo Soyuz Test Project. Goddard is planning to acquire Tracking and Data Relay Satellite System (TDRSS) services from industry beginning in late calendar year 1979.

Sounding Rockets - During 1975, more than 60 sounding rocket launchings, primarily from Wallops Flight Center, Virginia, were conducted by Goddard bringing the number of sounding rocket launchings in the program since 1959 to approximately 1,700.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
I. Personnel and Related Costs.....	86,920	87,630	90,440	22,861	23,990	89,679
II. Travel.....	2,251	2,255	2,439	631	631	2,288
III. Facilities Services.....	7,832	9,194	9,506	2,474	2,442	10,523
IV. Technical Services.....	2,807	1,914	1,763	508	508	1,864
V. Administrative Support.....	4,957	4,854	4,443	1,266	1,266	4,822
Total, fund requirements.....	104,767	105,847	108,591	27,740	28,837	109,176

Distribution of Permanent Positions by Program

Between the FY 1976 budget estimate and the current estimate, Goddard revised its distribution of positions to more accurately reflect the magnitude of the direct effort. Approximately three-fourths 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 Goddard's permanent positions:

Direct Positions						
Space Flight						
Space shuttle.....	---	7	23	7	25	14
Space flight operations.....	29	17	2	17	---	---
Expendable launch vehicles.....	73	60	121	60	121	114

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Space Science						
Physics and astronomy	1,058	987	1,019	987	1,019	933
Lunar and planetary exploration	141	140	144	140	144	109
Space Applications	648	673	649	673	649	727
Aeronautics and Space Technology						
Space research and technology	74	105	114	105	114	114
Tracking and Data Acquisition	663	706	695	706	695	709
Technology Utilization	7	7	6	7	6	6
Subtotal, direct positions	2,693	2,702	2,773	2,702	2,773	2,726
Indirect Positions						
Director and staff	17	17	18	17	18	18
Administrative support	744	778	682	778	682	661
Research and development support	299	257	274	257	274	270
Subtotal, indirect positions	1,060	1,052	974	1,052	974	949
Total, permanent positions	3,753	3,754	3,747	3,754	3,747	3,675

PERSONNEL AND RELATED COSTS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
I. PERSONNEL AND RELATED COSTS.....	86,920	87,630	90,440	22,861	23,990	89,679
Basis of Fund Requirements						
A. Compensation and Benefits						
1. Compensation						
a. Permanent positions.....	78,189	78,541	80,891	20,426	21,364	80,186
b. Nonpermanent.....	559	825	889	338	358	891
c. Overtime and Other Compensation.....	615	601	651	150	161	646
Subtotal, Compensation.....	79,363	79,967	82,431	20,914	21,883	81,723
2. Benefits.....	6,926	7,187	7,387	1,828	1,941	7,334
Subtotal, Compensation and Benefits.....	86,289	87,154	89,818	22,742	23,824	89,057
B. Supporting Costs						
1. Transfer of personnel.....	128	69	100	17	25	100
2. Personnel training.....	503	407	522	102	141	522
Subtotal, Supporting Costs.....	631	476	622	119	166	622
Total, Personnel and Related Costs.....	86,920	87,630	90,440	22,861	23,990	89,679

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
1. Compensation						
a. Permanent positions	78,189	78,541	80,891	20,426	21,364	80,186

The current estimate for 1976 is increased over the 1976 budget estimate due to the October 1975 pay raise which is partially offset by savings resulting from the manpower reduction from 3,754 positions to 3,747. The 1977 estimate reflects the reduction in permanent manpower from 3,747 positions to 3,675, with the cost of permanent positions decreasing $705 from 1976. This decrease results as follows:

Cost of permanent positions in FY 1976		80,891
Cost increases:		+3,078
Within grade advances and career development:		
Full year effect of FY 1976 and Transition Quarter actions	+798	
Partial year effect of FY 1977 actions	+1,217	
Full year effect of October 1975 pay raise	+1,063	
Cost decreases:		-3,783
Turnover savings:		
Full year effect of FY 1976 and Transition Quarter actions	-972	
Partial year effect of 1977 actions	-856	
One less paid day in 1977	-310	
Effect of 1977 manpower reduction	-1,645	
Cost of permanent positions in FY 1977		80,186

b. Nonpermanent						
Cost	$559	$825	$889	$338	$358	$891
Manyears	82	116	116	48	50	116

The 1977 estimate will support the following programs at approximately the levels indicated below:

Program	Manyears
College cooperative training	39
Summer employment	15
Opportunity programs	47
Other temporaries	15
Total	116

The current estimate for 1976 is increased from the 1976 budget estimate to reflect the cost of the October pay raise and a change in the mix of the various temporary programs. The 1977 estimate reflects the full year cost of these actions at the same program level as 1976.

	1975	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
			(Thousands of Dollars)			
c. Overtime and other compensation	615	601	651	150	161	646

Overtime at Goddard is required to meet peak operational requirements where additional man-hours of work are essential, generally culminating in the launch of a manned or automated spacecraft. Some of the areas involved are fabrication, experimentation, testing, launching and tracking of the spacecraft. The current estimate for 1976 is increased from the 1976 budget estimate to reflect the cost of the October pay raise and to pay for unanticipated requirements. These include replacement of valves on sprinkler systems, and overhaul of controls on the fire alarm system. The 1977 estimate reflects a slightly lower level of overtime than the 1976 estimate.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Benefits	6,926	7,187	7,387	1,828	1,941	7,334
Category of Cost						
Contribution to the Civil Service Retirement Fund	5,475	5,511	5,652	1,432	1,449	5,613
Contribution for employee life insurance	266	275	356	71	94	353
Contribution for employee health insurance	1,062	1,331	1,266	302	371	1,255
Contribution to FICA	18	27	29	11	5	29
Incentive awards	50	35	50	10	13	50
Other personnel benefits	31	8	34	2	9	34
Severance	24	---	---	---	---	---
Total	6,926	7,187	7,387	1,828	1,941	7,334

The current estimate for 1976 is increased from the 1976 budget estimate due to the October 1975 pay raise, higher life insurance rates, the incentive awards program, and other personnel benefits. The current 1976 estimate and the 1977 estimate for incentive awards relfects 1975 actual experience. The increase in other personnel benefits reflects increased claims for educational allowances for overseas dependents associated with Goddard's tracking and data acquisition network.

B. Supporting Costs	631	476	622	119	166	622

Supporting personnel costs provide for the expense of moving employees to their initial duty station or reassignment and for maintaining and expanding the skill of the employees. These costs are summarized as follows:

1. Transfer of personnel	128	69	100	17	25	100

The current estimate for 1976 is increased from the 1976 budget estimate to reflect FY 1975 experience. The FY 1977 estimate is the same as the FY 1976 current estimate.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Personnel training.....	503	407	522	102	141	522

The increase from FY 1976 budget estimate to the FY 1976 current estimate is due to increased tuition costs, increased utilization of basic procurement courses, development of a new course for project managers, and upgrading of training for supervisors. FY 1977 is planned at the FY 1976 level.

TRAVEL

II. TRAVEL.....	2,251	2,255	2,439	631	631	2,288

Approximately 85% of Goddard's funds are directly related to the Center's research and development programs. Project management personnel must travel 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, Goddard responsibilities necessitate travel to the stations in the world-wide tracking and data network for instrumentation of the sites and inspection prior to launch. The experts in the disciplines related to Goddard's science and applications responsibilities need to travel to scientific meetings and technical sessions.

The current estimate for 1976 is increased from the 1976 budget estimate to reflect the effect of higher per diem and mileage allowances, as partially offset by the effect of programs instituted to reduce travel costs. The decrease in 1977 reflects the full year effect of these programs.

Basis of Fund Requirements

Summary of Travel by Major Category

A. Program travel.....	1,687	1,919	2,079	541	541	1,944
B. Meetings travel.....	210	235	254	63	63	240
C. Administrative travel.....	354	101	106	27	27	104
Total.....	2,251	2,255	2,439	631	631	2,288

FACILITIES SERVICES

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)					
III. FACILITIES SERVICES	7,832	9,194	9,506	2,474	2,442	10,523

Basis of Fund Requirements

Summary of Facilities Services

A. Rental of Real Property	1,162	1,266	1,533	286	254	1,300
B. Maintenance and Related Services						
1. Maintenance of buildings and grounds	1,075	1,065	1,184	278	278	1,017
2. Custodial services	1,390	1,417	1,395	372	372	1,646
3. Maintenance of equipment	271	275	306	83	83	302
Subtotal	2,736	2,757	2,885	733	733	2,965

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
C. Operation of Facilities						
1. Utilities	3,408	4,145	4,619	1,086	1,250	5,690
2. Supplies and equipment	526	1,026	469	369	205	568
Subtotal	3,934	5,171	5,088	1,455	1,455	6,258
Total, Facilities Services	7,832	9,194	9,506	2,474	2,442	10,523
Basis of Fund Requirements Summary of Facilities Services						
A. Rental of Real Property	1,162	1,266	1,533	286	254	1,300

The current estimate for 1976 is increased from the 1976 budget estimate due to an unanticipated lease extension and increase in rent, partially offset by the reduction in GSA rates for property rentals. The 1977 estimate is based on GSA projections and reflects the consolidation of office and laboratory requirements to eliminate the need for one building.

B. Maintenance and Related Services	2,736	2,757	2,885	733	733	2,965
1. Maintenance of buildings and grounds	1,075	1,065	1,184	278	278	1,017

This covers maintenance, repair, alterations, and minor construction for 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 1976 is increased from the 1976 budget estimate to accommodate one-time requirements such as repairing roads, replacing floor tiles, and caulking windows to conserve energy, partially offset by a reduction of five manyears in the level of contractor support. The reduction from 1976 to 1977 reflects completion of these one-time projects.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Custodial Services.....	1,390	1,417	1,395	372	372	1,646

The decrease from the 1976 budget estimate to the current estimate is due to a reduction of 11 man-years of effort, partially offset by contractor wage increases. The increase from 1976 to 1977 provides for a full 12 months of funding for support service contracts and the full year effect of contractor wage increases.

3. Maintenance of Equipment.....	271	275	306	83	83	302

The increase from the 1976 budget to the 1976 current estimate is due to contractor wage increases for the maintenance of typewriters, calculators, copiers, and miscellaneous mechanical and shop equipment. The decrease in 1977 reflects essentially the 1976 level of services.

C. Operation of Facilities.....	3,934	5,171	5,088	1,455	1,455	6,258
1. Utilities.....	3,408	4,145	4,619	1,086	1,250	5,690

Fuel oil, previously budgeted under "Supplies and Equipment", is included under "Utilities" in order to portray accurately the full cost of utilities. The increase from the 1976 budget estimate to the 1976 current estimate is due to the increased use of fuel oil, partially offset by a reduction in estimated electricity consumption due to energy conservation measures. The increase from the 1976 estimate to the 1977 estimate is due to the full year effect of higher electricity and fuel oil costs.

2. Supplies and Equipment.....	526	1,026	469	369	205	568

The current estimate for 1976 is decreased from the 1976 budget estimate to reflect a deferral of purchases in order to partially fund the one-time maintenance projects mentioned above and the transfer of fuel oil from "Supplies and Equipment" to "Utilities." The 1977 estimate reflects the full annual requirement for supplies, materials, and equipment needed to maintain and operate Goddard's facilities.

TECHNICAL SERVICES

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
IV. TECHNICAL SERVICES	2,807	1,914	1,763	508	508	1,864

Basis of Fund Requirements
Summary of Technical Services

A. Automatic Data Processing						
1. Equipment	261	237	201	66	66	221
2. Programming and operations	976	875	728	224	224	869
Subtotal	1,237	1,112	929	290	290	1,090
B. Engineering Services	109	89	84	21	21	84
C. Scientific and Technical Information and Educational Programs						
1. Operations of technical libraries	329	357	323	100	100	294
2. Educational/Informational programs	320	227	333	65	65	273
3. Scientific and technical information	812	129	94	32	32	123
Subtotal	1,461	713	750	197	197	690
Total, Technical Services	2,807	1,914	1,763	508	508	1,864

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Basis of Fund Requirements
Summary of Technical Services

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
A. Automatic Data Processing.....	1,237	1,112	929	290	290	1,090

The decrease from the 1976 budget estimate to the current estimate is due to actual contract negotiations and a reduction of two manyears in the operations contract. The change from 1976 to 1977 reflects a full year of funding of contractual cost increases, partially offset by a reduction of three manyears in the programming contract.

B. Engineering Services.....	109	89	84	21	21	84

The decrease from the 1976 budget estimate to the 1976 current estimate reflects completion of the facility alteration and modification projects required to implement Goddard's organizational realignments. The 1977 estimate provides for continuation of the lower level of activity.

C. Scientific and Technical Information and Educational Programs.....	1,461	713	750	197	197	690
1. Operation of technical libraries..	329	357	323	100	100	294

The decrease from the 1976 budget estimate to the 1976 current estimate reflects a reduction in book purchases and other planned activities. The decline from 1976 to 1977 reflects the full year effect of 1976 reductions.

2. Educational/Informational Program.....	320	227	333	65	65	273

The increase from the 1976 budget to the 1976 current estimate is due to the procurement of additional exhibits for the Visitors Information Center in preparation for the bicentennial celebration. The decrease from 1976 to 1977 reflects completion of one-time bicentennial activities.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
3. Scientific and Technical Information	812	129	94	32	32	123

The 1975 figure includes $630 of one-time expenses associated with the "Outlook for Space" effort. The decrease between the 1976 budget and the 1976 current estimate and the increase in 1977 results from a rephasing of graphics and contractual services for various handbooks in need of updating.

ADMINISTRATIVE SUPPORT

V. ADMINISTRATIVE SUPPORT	4,957	4,854	4,443	1,266	1,266	4,822

Basis of Fund Requirements

Summary of Administrative Support

A. Communications						
1. Leased lines and long distance tolls	752	829	850	212	212	918
2. Local telephone service	1,033	983	1,008	257	257	1,085
3. Other communications	19	14	14	4	4	15
Subtotal	1,804	1,826	1,872	473	473	2,018
B. Administrative Printing	100	107	103	30	30	107
C. Supplies, Materials, and Equipment	1,055	895	830	231	231	671

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)					
D. Transportation						
1. Center operations	1,369	1,391	1,137	365	363	1,541
2. Common carrier	18	19	5	---	2	5
Subtotal	1,387	1,410	1,142	365	365	1,546
E. Administrative Support Services						
1. Installation support services	276	285	195	80	80	122
2. Occupational medicine and environmental health	335	331	301	87	87	358
Subtotal	611	616	496	167	167	480
Total, Administrative Support Service	4,957	4,854	4,443	1,266	1,266	4,822
A. Communications	1,804	1,826	1,872	473	473	2,018

The increase from the 1976 budget to the 1976 current estimate is due to higher local telephone rates. The increase from 1976 to 1977 current estimate is due to the full year effect of these rate increases and higher FTS charges.

B. Administrative Printing	100	107	103	30	30	107

The 1976 current estimate and the FY 1977 estimate reflect continuation of these services at the 1975 level.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)					
C. Supplies, Materials, and Equipment....	1,055	895	830	231	231	671

The decrease from the 1976 budget estimate to the 1976 current estimate is due to reductions made to fund urgent requirements in other areas. The decrease from 1976 to 1977 reflects efforts to optimize the management of supplies and materials.

D. Transportation.....	1,387	1,410	1,142	365	365	1,546

The decrease from the 1976 budget estimate to the 1976 current estimate is due to a reduction of two manyears and rephasing of the contract funding plan. The 1977 estimate reflects a full year's funding at the current level of support.

E. Administrative Support Services.....	611	616	496	167	167	480

The change from the 1976 budget to current estimate reflects a reduction of nine manyears from the 1976 budget and rephasing of the contract funding plan. The 1977 amount reflects a full year funding for these services and a further reduction of nine manyears.

WALLOPS FLIGHT CENTER

DESCRIPTION

Wallops Flight Center includes three separate areas on the Atlantic Coast of Virginia's eastern shore: the main base, the Wallops Island launching site, and the Wallops mainland site. The administrative offices, range control center, support shops, and main telemetry buildings are located on the main base. Wallops Island is about seven miles southeast of the main base and is connected to the mainland by a causeway and bridge. The island is about five miles long and one-half mile wide at its widest point. Located on the island are rocket storage buildings, blockhouses, assembly shops and launch sites. The Wallops mainland site is a one-half mile strip west of the island which houses the radar and optical tracking sites.

Wallops Flight Center, totalling 6,563 acres, consists of 2,230 acres on the main base, 3,085 acres on Wallops Island, 108 acres on the mainland tracking site, and 1,140 acres of marsh land. The total capital investment, including fixed assets in progress and contractor-held facilities at various locations, as of June 30, 1975, was $126,811,000.

MISSION

Wallops Flight Center prepares, assembles, launches, and tracks space vehicles and acquires scientific information from them. 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. Seventeen satellites have been launched. Wallops Flight Center has launched approximately 9,000 research vehicles consisting of from one to seven stages in quest of 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 test on grooved runways, collision avoidance programs, and laser and radar tracking of aircraft and satellites.

Wallops Flight Center exercises project management responsiblity 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 systems engineering, test and evaluation; and data analysis and reporting.

Wallops Flight Center is also active in 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 visit Wallops Flight Center to observe operations or seek assistance in establishing sounding rocket facilities of their own.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1975	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
			(Thousands of Dollars)			
I. Personnel and Related Costs.....	8,303	8,527	8,815	2,197	2,292	9,104
II. Travel.....	265	251	270	123	123	274
III. Facilities Services.....	2,828	2,920	2,946	877	877	3,234
IV. Technical Services.....	213	274	262	17	17	235
V. Administrative Support.....	767	733	761	329	329	807
Total, fund requirement.....	12,376	12,705	13,054	3,543	3,638	13,654

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.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
Direct Positions						
Space Flight						
Space flight operations	1	1	1	1	1	---
Expendable launch vehicles	3	3	3	3	3	3
Space Science						
Physics and astronomy	63	63	62	63	62	59
Lunar and planetary exploration	1	1	1	1	1	---
Space Applications	57	63	57	63	57	59
Aeronautics and Space Technology						
Aeronautical research and technology	18	18	18	18	18	20
Space research and technology	2	2	2	2	2	2
Tracking and Data Acquisition	99	99	99	99	99	99
Technology Utilization	---	---	1	---	1	1
Subtotal, direct positions	244	250	244	250	244	243
Indirect Positions						
Director and staff	6	6	6	6	6	6
Administrative support	73	72	73	72	73	73
Research and development support	93	87	92	87	92	92
Subtotal, indirect positions	172	165	171	165	171	171
Total, permanent positions	416	415	415	415	415	414

PERSONNEL AND RELATED COSTS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
I. PERSONNEL AND RELATED COSTS.....	8,303	8,527	8,815	2,197	2,292	9,104
Basis of Fund Requirements						
A. Compensation and Benefits						
1. Compensation						
a. Permanent positions.....	7,258	7,411	7,648	1,902	1,987	7,895
b. Nonpermanent.....	149	206	207	60	58	210
c. Reimbursable detailees.....	---	---	10	---	5	20
d. Overtime and other compensation	133	118	139	32	33	141
Subtotal, Compensation.....	7,540	7,735	8,004	1,994	2,083	8,266
2. Benefits.....	705	731	750	188	194	777
Subtotal, Compensation and Benefits.....	8,245	8,466	8,754	2,182	2,277	9,043
B. Supporting Costs						
1. Transfer of personnel.....	3	6	6	---	---	6
2. Personnel training.....	55	55	55	15	15	55
Subtotal, Supporting Costs.....	58	61	61	15	15	61
Total, Personnel and Related Costs.....	8,303	8,527	8,815	2,197	2,292	9,104

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
1. Compensation	7,540	7,735	8,004	1,994	2,083	8,266
a. Permanent positions	7,258	7,411	7,648	1,902	1,987	7,895

The 1976 and Transition Quarter current estimates are increased from the 1976 budget due to the October 1975 pay raise. The increase in 1977 reflects the full year cost of the pay raise, partially offset by savings resulting from 1977 manpower reduction from 415 to 414 positions.

Basis of Cost for Permanent Positions

In 1977 the cost of permanent positions will be $7,895, an increase of $247 from 1976. This increase is calculated as follows:

Cost of permanent positions in 1976		7,648
Cost increases in 1976		+333
Within grade advances and career development:		
Full year effect of 1976 and transition quarter actions	+122	
Partial year effect of 1977 actions	+120	
Full year effect of October 1975 pay raise	+91	
Cost decreases in 1976		-86
Turnover savings:		
Full year effect of 1976 and transition quarter actions	-12	
Partial year effect of 1977 actions	-32	
One less work day in 1977	-27	
Partial year effect of 1977 manpower reduction	-15	
Cost of permanent positions in 1977		7,895

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
b. Nonpermanent						
1. Cost	$149	$206	$207	$60	$58	$210
2. Manyears	31	33	31	10	10	31

The 1976 estimate includes the October 1975 pay raise which is partially offset by a reduction of two co-op positions. The 1977 budget estimate reflects the full year effect of the October 1975 pay raise. The 1977 estimate will support the following programs at approximately the levels indicated below:

Distribution of Nonpermanent Manyears by Program

Program	Manyears
College cooperative training	12
Summer employment	3
Opportunity programs	14
Other temporary employment	2
Total	31

c. Reimbursable detailees	---	---	10	---	5	20

The services of one military pilot will be utilized beginning in 1976 in support of the Center's aeronautical projects.

d. Overtime and other compensation	133	118	139	32	33	141

Overtime funds are required at Wallops primarily to meet operational requirements of the sounding rocket programs of the Physics and Astronomy and Space Applications programs. Many factors beyond the Center's control, such as launch schedules, weather holds, and range clearance problems necessitate work beyond normal hours to operate the launch facilities, provide instrumentation support, and conduct tracking and data acquisition activities required to assure mission success. The increase in 1976 over the budget estimate reflects 1975 experience, October 1975 pay raise and currently identifiable requirements.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Benefits	705	731	750	188	194	777

The current estimate for 1976 is increased over the budget estimate to account for the higher cost of health insurance premiums and the October 1975 pay raise. The 1977 budget estimate reflects the full year cost of these actions.

The following table indicates the cost of personnel benefits by the major categories:

Category of Costs						
Contribution to the Civil Service Retirement Fund	510	524	533	134	138	555
Contribution for employees life insurance	31	30	32	8	8	33
Contribution for employees health insurance	149	165	173	42	44	177
Contribution to FICA	5	9	9	2	2	9
Incentive awards	1	1	1	1	1	1
Other benefits	9	2	2	1	1	2
Total	705	731	750	188	194	777
B. Supporting Costs	58	61	61	15	15	61
1. Transfer of personnel	3	6	6	---	---	6

The estimates for 1976 and 1977 provide for a continuation at the 1976 budget estimate level of effort. Most recent experience indicates that on the average one move per year occurs.

2. Personnel training	55	55	55	15	15	55

The estimate for 1976 and 1977 provide for a continuation at the 1976 budget estimate level.

TRAVEL

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
II. TRAVEL	265	251	270	123	123	274

Half of Wallops's travel funds support the Center's Research and Development programs. The travel function also includes the cost of the support contractor operated shuttle bus service. The amount requested for 1977 provides for trips to locations thoroughout the United States and other countries in support of the Center's program. Sounding Rockets, SEASAT, GEOS-C and Earth Resources account for most of the trips in this country. Travel to foreign countries in support of the launches and to tracking sites is required for:

International Cooperative Meteorological Program - Trips to Brazil, Peru, Spain, and the Soviet Union.

Sounding Rocket Support - Trips to Canada, Sweden, Kenya, England, Israel, France, and New Guinea.

The current estimate increase from the 1976 budget estimate allows for the higher per diem rates approved by Congress in May 1975. The increase in 1977 for Administrative Travel reflects the full year cost of the negotiated wage increases for the shuttle bus contractor employees.

Basis of Fund Requirements
Summary of Travel by Major Category

A. Program Travel	129	131	138	35	35	138
B. Meetings and Technical Seminars	21	17	22	4	4	22
C. Administrative Travel	115	103	110	84	84	114
Total, Travel	265	251	270	123	123	274

FACILITIES SERVICES

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
III. FACILITIES SERVICES.....	2,828	2,920	2,946	877	877	3,234

Basis of Fund Requirements

Summary of Facilities Services

A. Maintenance and Related Services						
1. Maintenance, repair and alterations of buildings and grounds.....	455	615	533	48	48	601
2. Custodial services.....	867	809	815	191	191	894
3. Maintenance of equipment.....	162	192	170	147	147	208
Subtotal.....	1,484	1,616	1,518	386	386	1,703
B. Operation of Facilities						
1. Utilities.....	1,009	645	1,131	382	435	1,220
2. Supplies and equipment.....	335	659	297	109	56	311
Subtotal.....	1,344	1,304	1,428	491	491	1,531
Total, Facilities Services.....	2,828	2,920	2,946	877	877	3,234
A. Maintenance and Related Services.....	1,484	1,616	1,518	386	386	1,703
1. Maintenance, repair and alterations of buildings and grounds.....	455	615	533	48	48	601

Over 330 buildings and approximately one million square feet of building space on 6,563 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 reduction in 1976 from the budget estimate reflects the deferral of minor maintenance and alteration projects to provide funds to cover unanticipated utility rate increases. The 1977 estimate provides for the deferred projects and reflects the full year cost of contractor wage increases effective in 1976.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Custodial services.....	867	809	815	191	191	894

This category includes fire protection, protective guard service, materials to provide janitorial services for 100 buildings and 711,325 square feet of floor space; store operations, inventory and cataloging. The change from the 1976 budget to current estimate reflects a reduction of ten manyears from the 1976 budget and the minimum obligation required in 1976 in order to provide funds for increased labor rates in the custodial support contracts. The 1977 estimate reflects the full year cost of these actions.

3. Maintenance of equipment.....	162	192	170	147	147	208

The reduction in 1976 from the budget estimate reflects the deferral of equipment maintenance effort to allow for unanticipated cost increases in other areas not fully covered in the 1976 budget. The increase in 1977 provides for a return to the 1975 level of maintenance and for wage increases in the heating plant operations contract effective in 1976.

B. Operation of Facilities.....	1,344	1,304	1,428	491	491	1,531
1. Utilities.....	1,009	645	1,131	382	435	1,220

The increase in 1976 from the budget estimate reflects the reclassification of fuel oil costs from the supplies and equipment subfunction so that the total cost of utilities is reflected in one subfunction. The increase in 1977 provides for the full year cost of fuel oil and electricity rate increases occurring in 1976.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Supplies and equipment.....	335	659	297	109	56	311

Provides for the purchase of supplies and equipment in support of the physical plant. The reduction from the 1976 budget estimates reflects the reclassification of fuel oil costs from this subfunction to utilities, above.

TECHNICAL SERVICES

IV. TECHNICAL SERVICES.....	213	274	262	17	17	235

Basis of Fund Requirements

Summary of Technical Services

A. Automatic Data Processing						
1. Equipment.....	20	39	61	2	2	22
2. Programming and operation.....	58	106	58	---	---	64
Subtotal.....	78	145	119	2	2	86
B. Engineering Services.....	11	33	10	---	---	10
C. Scientific and Technical Information and Educational Programs						
1. Operation of NASA technical library.....	121	88	125	13	13	131
2. Educational/informational programs.....	3	8	8	2	2	8
Subtotal.....	124	96	133	15	15	139
Total, Technical Services.....	213	274	262	17	17	235

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)					
A. Automatic Data Processing.....	78	145	119	2	2	86

Provides for the lease, maintenance, operations, programming and analysis, and supplies of all ADP equipment not applicable to Research and Development. The current estimate for 1976 is reduced to reflect savings in the programming and operations contract through recompetition, partially offset by the one-time cost of purchasing previously leased remote terminals. The decrease in 1977 reflects normal equipment requirements.

B. Engineering Services.....	11	33	10	---	---	10

Provides for the planning of facility activation and major facility modification. The current estimate for 1976 and 1977 reflects 1975 experience.

C. Scientific and Technical Information and Educational Programs.....	124	96	133	15	15	139
1. Library services.....	121	88	125	13	13	131

The funds provide primarily for support contract operation of the Wallops Research Library. The library consists of 3,645 square feet of floor space with seating capacity for 45. There are 21,596 books; 2,161 bound periodicals; 440 magazine subscriptions; 19,400 hardcopy technical reports; and approximately 700,000 microfiche reports. The increase in 1976 and 1977 reflects the current labor rates which were negotiated in 1975.

2. Educational programs.....	3	8	8	2	2	8

Provides for the vistors center, exhibits, and public information releases. Funding remains level between 1976 and 1977.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)					
V. ADMINISTRATIVE SUPPORT.....	767	733	761	329	329	807

Basis of Fund Requirements

Summary of Administrative Support

A. Communications						
1. Leased lines and long distance.....	4	6	6	6	6	6
2. Local telephone service.....	100	122	122	122	122	122
3. Other communications.....	---	---	---	---	---	---
Subtotal, Communications.....	104	128	128	128	128	128
B. Administrative Printing.....	61	62	66	62	69	73
C. Supplies, Materials and Equipment..	513	458	489	98	98	522
D. Transportation						
1. Center operations.....	52	36	36	13	13	42
2. Common carrier.....	23	23	23	2	2	23
Subtotal, Administrative Printing.....	75	59	59	15	15	65
E. Administrative Support Services						
1. Installation support services..	1	1	1	1	1	1

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	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
E. Administrative Support Services (Cont'd)						
2. Occupational medicine and environmental health.....	13	25	18	25	18	18
Subtotal, Administrative Support Services.....	14	26	19	26	19	19
Total, Administrative Support.....	767	733	761	329	329	807
A. Communications.....	104	128	128	128	128	128

Provides for the local telephone and exchange service, Federal Telecommunications Service, and leased and long distance telephone tolls. Funding remains level in 1977.

B. Administrative Printing.....	61	62	66	62	69	73

Provides for contracted services of printing, reproduction, microfilming, etc., in support of administrative requirements. The increases in 1976 and 1977 reflect contractual wage rates effective in 1976.

C. Supplies, Materials and Equipment....	513	458	489	98	98	522

Provides for general operating and service materials, photographic and electronic materials, furniture, office and photographic equipment. The increase in 1976 from the budget estimate reflects current price levels which are higher than those anticipated in the 1976 budget. The increase in 1977 reflects the full year effect of price increases experienced in 1976.

D. Transportation.....	75	59	59	15	15	65

Provides for the operation of the motor pool, common carrier, and maintenance and repair of the administrative aircraft. The 1977 budget estimate reflects increased cost for maintenance and repair.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)					
E. Administrative Support Services.....	14	26	19	26	19	19

Provides for contracted medical services. The 1976 current estimate reflects a reduction in costs due to renegotiation of the medical services contract. Funding remains level in 1977.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
ORGANIZATION AND STAFFING CHART
WALLOPS FLIGHT CENTER

STAFFING SUMMARY

	CY 76	BY 77
Excepted	2	2
GS-16	2	2
GS-15	12	12
GS-14	25	25
All Other GS	332	331
Wage Grade	42	42
Total Permanent	415	414

DIRECTOR

	CY	BY
Excepted	2	2
GS-16	0	0
GS-15	3	3
GS-14	0	0
All Other GS	2	2
Wage Grade	0	0
Total Permanent	7	7

OPERATIONS DIRECTORATE

	CY	BY
Excepted	-	-
GS-16	1	1
GS-15	2	2
GS-14	5	5
All Other GS	112	112
Wage Grade	0	0
Total Permanent	120	120

ENGINEERING DIRECTORATE

	CY	BY
Excepted	-	-
GS-16	1	1
GS-15	4	4
GS-14	12	11
All Other GS	72	73
Wage Grade	0	0
Total Permanent	89	89

ADMINISTRATION DIRECTORATE

	CY	BY
Excepted	-	-
GS-16	-	-
GS-15	2	1
GS-14	1	2
All Other GS	68	67
Wage Grade	0	0
Total Permanent	71	70

TECHNICAL SUPPORT DIRECTORATE

	CY	BY
Excepted	-	-
GS-16	-	-
GS-15	0	0
GS-14	1	1
All Other GS	69	69
Wage Grade	42	42
Total Permanent	112	112

APPLIED SCIENCE DIRECTORATE

	CY	BY
Excepted	-	-
GS-16	-	-
GS-15	1	2
GS-14	6	6
All Other GS	9	8
Wage Grade	0	0
Total Permanent	16	16

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, 1975, was $337,383,000.

MISSION

The programs at the Ames Research Center are directed toward research and development in the fields of aeronautics, space science, life science, and space 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; Flight Simulation Technology; theoretical, experimental, and computational fluid dynamics; Planetary Entry Systems Technology; Airborne Sciences and Applications; and Aeronautical and Life Sciences. In addition to the 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 and experimental 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. The Center also has responsibility for the management of the current Pioneer series of spacecraft and the associated planetary exploration missions including Pioneer Venus.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
I. Personnel and Related Costs.....	39,877	40,315	42,027	10,363	10,802	41,409
II. Travel.....	847	878	1,196	289	347	1,080
III. Facilities Services.....	4,872	5,618	4,972	1,403	1,293	5,489
IV. Technical Services.....	854	632	541	127	125	569
V. Administrative Support.....	2,121	1,814	1,825	567	621	1,971
Total, fund requirements.....	48,571	49,257	50,561	12,749	13,188	50,518

Distribution of Permanent Positions by Program

Approximately three-fourths 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.

		1976		Transition Quarter		1977
	1975	Budget	Current	Budget	Current	Budget
Direct Positions	Actual	Estimate	Estimate	Estimate	Estimate	Estimate
			(Thousands of Dollars)			
Space Flight						
Space shuttle	3	3	---	3	---	---
Space flight operations	6	12	8	12	8	7
Space Sciences						
Physics and astronomy	77	84	67	84	67	66
Lunar and planetary exploration	173	159	193	159	193	186
Life sciences	107	107	104	107	104	104
Applications						
Space applications	66	51	71	51	71	63
Aeronautics and Space Technology						
Aeronautical research and technology	590	564	607	564	607	584
Space research and technology	207	210	176	210	176	172
Technology Utilization	10	7	11	7	11	11
Subtotal, direct positions	1,239	1,197	1,237	1,197	1,237	1,193
Indirect Positions						
Director and staff	43	34	43	34	43	41
Administrative support	241	235	241	235	241	232
Research and development support	155	210	155	210	155	147
Subtotal, indirect positions	439	479	439	479	439	420
Total, permanent positions	1,678	1,676	1,676	1,676	1,676	1,613

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
			PERSONNEL AND RELATED COSTS			
I. PERSONNEL AND RELATED COSTS.....	39,877	40,315	42,027	10,363	10,802	41,409
			Basis of Fund Requirements			
A. Compensation and Benefits						
1. Compensation						
a. Permanent positions.....	35,235	35,754	37,107	9,040	9,436	36,532
b. Nonpermanent.....	573	501	558	220	228	566
c. Reimbursable details.....	207	225	297	72	75	297
d. Overtime and other compensation	423	376	400	115	118	405
Subtotal, compensation.....	36,438	36,856	38,362	9,447	9,857	37,800
2. Benefits.....	3,206	3,225	3,407	810	857	3,341
Subtotal, compensation and benefits.....	39,644	40,081	41,769	10,257	10,714	41,141
B. Supporting Costs						
1. Transfer of personnel.....	38	58	67	35	22	77
2. Personnel training.....	195	176	191	71	66	191
Subtotal, supporting costs.....	233	234	258	106	88	268
Total, personnel and related costs....	39,877	40,315	42,027	10,363	10,802	41,409

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
1. Compensation	36,438	36,856	38,362	9,447	9,857	37,800
a. Permanent positions	35,235	35,754	37,107	9,040	9,436	36,532

Basis of Cost for Permanent Positions

In 1977 the cost of permanent positions will be $36,532, a decrease of $575 from 1976. This results as follows:

Cost of permanent positions in 1976		37,107
Cost increases:		+1,507
Within grade advances and career development:		
Full year effect of 1976 and transition quarter actions	+393	
Partial year effect of 1977 actions	+512	
Full year effect of October 1975 pay raise	+602	
Cost decreases:		-2,082
Turnover savings:		
Full year effect of 1976 and transition quarter actions	-132	
Partial year effect of 1977 actions	-407	
One less paid day in 1977	-147	
1977 manpower reduction	-1,396	
Cost of permanent positions in 1977		36,532

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
b. Nonpermanent						
Cost	$573	$501	$558	$220	$228	$566
Manyears	86	77	77	34	34	77

The 1976 increase is due primarily to the October 1975 pay raise and the redistribution of nonpermanent manyears by program to emphasize the graduate intern program.

The increase in cost between 1976 and 1977 is due to the full year cost of the October 1975 pay raise.

The 1977 program includes 77 manyears to support the following programs:

Distribution of Nonpermanent Manyears by Program

	Manyears
College cooperative training	16
Summer employment	8
Youth opportunity	28
Other temporary employment	25
Total	77

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
c. Reimbursable details	207	225	297	72	75	297

The increase in the 1976 current estimate is due to the effect of the October 1975 pay raise.

Reimbursable details include 7 military officers and 5 civilians and are planned at the same funding level in 1977 as 1976.

d. Overtime and other compensation	423	376	400	115	118	405

Overtime and night differential are used primarily for off-shift operation of major wind tunnel facilities such as the Unitary Plan Wind Tunnel System, the 40-by-80-foot Wind Tunnel, and the 6-by-6-foot Supersonic Wind Tunnel. The 1976 current estimate increases over the budget estimate due to the October 1975 pay raise, plus minor increases required to support the previously underestimated wind tunnel testing activity. 1977 effort is planned at the 1976 level, and the increase is due to the full year effect of the October 1975 pay raise.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Benefits	3,206	3,225	3,407	810	857	3,341

The following table indicates the cost of personnel benefits by category:

Category of Cost						
Contribution to the Civil Service Retirement Fund	2,476	2,521	2,582	629	653	2,532
Contribution for employee life insurance	134	123	163	31	42	159
Contribution for employee health insurance	537	553	631	137	149	619
FICA	21	14	15	8	9	15
Incentive awards	15	14	16	5	4	16
Severance pay	23	---	---	---	---	---
Total	3,206	3,225	3,407	810	857	3,341

The increase in 1976 above the previous budget estimate is due to permanent compensation increases detailed above, as well as increased life insurance rates and the increased government contribution to health insurance.

The decrease in 1977 reflects the reduction in the number of permanent personnel.

B. Supporting Costs	233	234	258	106	88	268
1. Transfer of personnel	38	58	67	35	22	77

The increase in 1976 is due to certain transfers which were planned for 1975, but are actually taking place in 1976.

The estimate in 1977 increases because of higher transportation costs. The number of transfers is expected to be comparable to the 1976 level.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Personnel training.....	195	176	191	71	66	191

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 increase in the 1976 current estimate over the budget estimate allows for increase in tuition costs and other training fees.

TRAVEL

II.	TRAVEL.....	847	878	1,196	289	347	1,080

Over 70% of the ARC travel is for travel related to approved programs and projects such as the Infrared Astronomy Expedition to the Pacific and the Atlantic Missile Range; the Arctic Ice Dynamic Joint Experiment Mission to Alaska; the Stratospheric Sampling Missions in the Arctic, the Pacific, and Central America; and the travel called for by the projects Pioneer-Venus, Kosmos and Viking, as well as the ongoing research and technology efforts. The increase in the 1976 current estimate over the budget estimate results from additional reviews of travel requirements in relation to program activity and the increased per diem rates now in effect, as partially offset by programs instituted to reduce travel costs. The decrease in 1977 reflects the full year effects of these programs.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Basis of Fund Requirements						
Summary of Travel by Major Category						
A. Program Travel	568	629	898	207	256	788
B. Meetings and Technical Seminars	126	130	148	45	48	144
C. Administrative Travel	153	119	150	37	43	148
Total Travel	847	878	1,196	289	347	1,080
FACILITIES SERVICES						
III. FACILITIES SERVICES	4,872	5,618	4,972	1,403	1,293	5,489
Basis of Fund Requirements						
Summary of Facilities Services						
A. Maintenance and Related Services						
1. Maintenance, repair, and alteration of buildings and grounds	287	209	289	12	10	289
2. Custodial services	1,051	1,035	958	335	287	1,034
3. Maintenance of equipment	64	64	64	16	16	64
Subtotal	1,402	1,308	1,311	363	313	1,387

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)					
B. Operation of Facilities						
1. Utilities	3,064	4,150	3,501	1,000	949	3,942
2. Supplies and equipment	406	160	160	40	31	160
Subtotal	3,470	4,310	3,661	1,040	980	4,102
Total, Facilities Service	4,872	5,618	4,972	1,403	1,293	5,489
A. Maintenance and Related Services	1,402	1,308	1,311	363	313	1,387
1. Maintenance, repair, and alteration of buildings and grounds	287	209	289	12	10	289

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. This maintenance includes scheduled one-time repairs for roads, walks, aircraft taxiway, as well as recurring roofing, painting, and electrical repairs. The 1976 current estimate maintains the level of 1975 requirements, and reflects the escalation of construction labor and materials cost within the period between the 1976 budget estimate and the 1976 current estimate. The 1977 estimate remains at the 1976 level.

2. Custodial services	1,051	1,035	958	335	287	1,034

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. 1976 current estimate reflects a reduction of seven manyears from the 1976 budget estimate in janitorial services. In 1977, this reduction will be offset by an increase of about three manyears in the firefighter and other services to be provided by the U.S. Navy, Moffett, for the ARC Facility at Crows Landing.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
3. Maintenance of equipment.....	64	64	64	16	16	64

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.

B. Operation of Facilities.....	3,470	4,310	3,661	1,040	980	4,102
1. Utilities.....	3,064	4,150	3,501	1,000	949	3,942

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 current estimate was reduced from the 1976 budget estimate to reflect 1975 experience with the current rate structure and consumption level.

The 1977 increases result from rate increases approved by the California Public Utilities Commission for the Pacific Gas & Electric Company, and the rate increases of the U.S. Bureau of Reclamation, Dept. of the Interior, effective on January 1, 1976.

2. Supplies and equipment.....	406	160	160	40	31	160

Supply and equipment purchases include building, shop, electrical, fuels, lubricants and general maintenance and replacement equipment needed for maintenance and repair of facilities. Obligations in 1975 of $221 included the one-time cost for purchase of previously leased equipment.

TECHNICAL SERVICES

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
IV. TECHNICAL SERVICES	854	632	541	127	125	569

Basis of Fund Requirements

Summary of Technical Services

A. Automatic Data Processing	496	278	278	72	71	292
1. Programming and operations	496	278	278	72	71	292
B. Engineering Services	14	---	10	---	---	15
C. Scientific and Technical Information and Education Programs	344	354	253	55	54	262
1. Educational/information programs	344	354	253	55	54	262
Total, Technical Services	854	632	541	127	125	569
A. Automatic Data Processing	496	278	278	72	71	292

Obligations for administrative ADP operation and programming reflects that portion of the ADP Central Facility operating costs which are incurred by administrative organizations. These costs are incurred through a system whereby user organizations are charged for actual usage of the ADP central facility's equipment and services. Reduced obligations in 1976 and 1977 compared to 1975 reflect the reduced rates brought about by the greater efficiency of the ADP equipment recently acquired by the Central Facility, and the procurement of administrative programming services contracted by GSA.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)					
B. Engineering Services.....	14	---	10	---	---	15

1975 costs were Ames' proportionate share of the costs DoD incurred in representing the Federal agencies before the State P.U.C. in connection with public utility rate hearings. A similar assessment is expected for utility rate hearings in 1976 and 1977.

C. Scientific and Technical Information and Educational Programs.....	344	354	253	55	54	262
1. Educational/information programs..	344	354	253	55	54	262

This function includes contract support and other costs for public information, public services (e.g., tour guide, etc.), media development (e.g., public exhibits, etc.), and educational programs. Increase in 1977 estimate over 1976 reflects the average price increases of items procured for public information activities. The 1976 current estimate decreases from the budget estimate because of the earlier than planned completion of Pioneer/Jupiter encounter public affairs activities.

ADMINISTRATIVE SUPPORT

V. ADMINISTRATIVE SUPPORT.....	2,121	1,814	1,825	567	621	1,971

Basis of Fund Requirements

Summary of Administrative Support

A. Communications						
1. Leased lines and long distance tolls.....	287	314	314	75	84	340
2. Local telephone service.....	383	419	409	105	115	446
3. Other communications.....	9	---	10	---	2	12
Subtotal.....	679	733	733	180	201	798

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
B. Administrative Printing.....	47	75	65	20	20	65
C. Supplies, Materials, and Equipment....	341	211	211	52	52	211
D. Transportation						
1. Center operations.....	32	54	54	19	21	59
2. Common carrier.....	37	39	39	13	14	42
Subtotal.....	69	93	93	32	35	101
E. Administrative Support Services						
1. Installation support services.....	798	513	513	133	147	564
2. Environmental health and occupational medicine.....	187	189	210	150	166	232
Subtotal.....	985	702	723	283	313	796
Total, Administrative Support Services....	2,121	1,814	1,825	567	621	1,971
A. Communications.....	679	733	733	180	201	798

Communications services are provided by GSA (for FTS) and the Pacific Telephone and Telegraph Company (PT&T). Other communications consist of teletype equipment and services provided by Western Union. The increase in obligations for the Transition Quarter and 1977 reflect rate increases now before the State P.U.C. for public hearings which will become effective in 1976.

B. Administrative Printing.....	47	75	65	20	20	65

The decrease in 1976 from the budget estimate to the current estimate is due to a reevaluation of 1976 requirements. 1977 requirements are planned at the same level as in 1976.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)					
C. Supplies, Materials, and Equipment....	341	211	211	52	52	211

This item includes office supplies and materials, and office furniture and equipment. Funding requirements in 1977 are at the 1976 level.

D. Transportation.....	69	93	93	32	35	101

This category includes rentals of GSA vehicles (other than passenger-carrying vehicles), vehicle fuel, oil and parts, and repair and maintenance. Common carrier includes freight charges, local drayage, parcel post and air freights. Increases in 1977 reflect full year effect of price increases for vehicle fuel, oil, and parts.

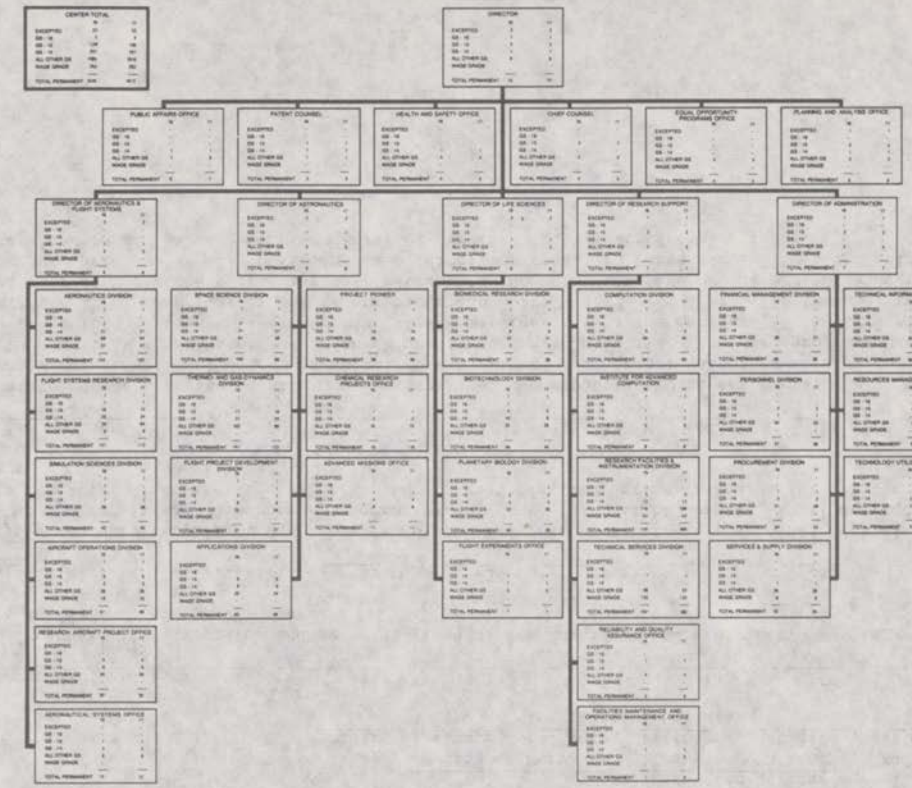
E. Administrative Support Services.....	985	702	723	283	313	796

Administrative support services consist predominantly of two support service contracts, one of which provides supply management, mail, and pickup/delivery services, and another which provides medical services. The first is an SBA contract in the Minority Business Enterprise (Sec. 8a) program where labor costs are guided by the Dept. of Labor's "Wage Determinations." The decrease in the 1976 estimate, compared to 1975, is primarily due to non-recurring costs expended in 1975. The increase in the 1976 current estimate over the budget estimate represents the price increase of the medical support service contract, principally the physicians' and laboratory fees. Increases in 1977 reflect price increases required to maintain the minimum level of services at the current labor rates.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORGANIZATION AND STAFFING CHART

AMES RESEARCH CENTER



RPM 7-16

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 511 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 and shuttle support facilities. Auxiliary buildings include warehouses, an auxiliary power systems building, 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, 1975, was $78,172,000.

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 and improved cost-effective methods of conducting flight research. The Space Shuttle program plans require that the Shuttle Carrier Aircraft (SCA) tests and the Orbital Approach and Landing Tests (ALT) be conducted at the Flight Research Center. Functioning in the role as the host Center to the ALT team involves responsibilities associated with the development of test support facilities, the institutional support of the ALT operations base and flight and industrial safety for ALT operations.

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 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

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
I. Personnel and Related Costs.....	10,903	11,346	11,548	3,003	3,144	11,821
II. Travel.....	221	242	256	84	84	262
III. Facilities Services.....	1,605	1,609	1,745	1,500	1,500	2,735
IV. Technical Services.....	71	76	76	52	52	78
V. Administrative Support.....	446	441	472	268	268	936
Total, fund requirements.....	13,246	13,714	14,097	4,907	5,048	15,832

Distribution of Permanent Positions by Program

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
Direct Positions						
Space Flight						
Space shuttle	30	88	76	88	82	87
Space Science						
Life Sciences	2	1	1	1	1	1
Aeronautics and Space Technology						
Aeronautical research and technology	301	278	287	278	291	286
Space research and technology	34	---	10	---	---	---
Tracking and Data Acquisition	28	28	28	28	28	28
Technology Utilization	1	1	1	1	1	1
Subtotal, direct positions	396	396	403	396	403	403
Indirect Positions						
Director and staff	17	17	17	17	17	17
Administrative support	77	76	77	76	77	77
Subtotal, indirect positions	94	93	94	93	94	94
Total, permanent positions	490	489	497	489	497	497

PERSONNEL AND RELATED COSTS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
I. PERSONNEL AND RELATED COSTS.....	10,903	11,346	11,548	3,003	3,144	11,821
Basis of Fund Requirements						
A. Compensation						
1. Compensation						
a. Permanent positions.....	9,404	9,762	9,916	2,541	2,663	10,144
b. Nonpermanent.....	348	415	418	153	159	424
c. Reimbursable detailees.....	120	132	104	39	26	117
d. Overtime and other compensation	89	95	98	24	25	100
Subtotal, Compensation.....	9,961	10,404	10,536	2,757	2,873	10,785
2. Benefits.....	888	892	962	233	258	986
Subtotal, Compensation and Benefits.....	10,849	11,296	11,498	2,990	3,131	11,771
B. Supporting Costs						
1. Transfer of personnel.....	13	10	10	3	3	10
2. Personnel training.....	41	40	40	10	10	40
Subtotal, Supporting Costs....	54	50	50	13	13	50
Total, Personnel and Related Costs.....	10,903	11,346	11,548	3,003	3,144	11,821

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
1. Compensation	9,961	10,404	10,536	2,757	2,873	10,785
a. Permanent positions.....	9,404	9,762	9,916	2,541	2,663	10,144

The current estimate for 1976 is increased from the 1976 budget estimate to reflect the cost of the October 1975 pay raise, plus the cost of the permanent ceiling increase of 8 positions. The increase in 1977 reflects the full year cost of these actions.

The estimate for compensation is based upon 497 permanent positions at the beginning and end of year, modified by turnover, promotions and within grade advances.

Basis of Cost for Permanent Positions

In 1977, the cost of permanent positions will be $10,144, an increase of $228 from 1976. This increase is calculated as follows:

Cost of permanent positions in 1976.....		9,916
Cost increases in 1977.....		+454
Within grade advances and career development:		
Full year effect of 1976 and transition quarter actions.....	+145	
Partial year effect of 1977 actions.....	+92	
Full year effect of October 1975 pay raise.....	+121	
Full year effect of new positions in 1976.....	+96	
Cost decreases in 1977.....		-226
Turnover savings:		
Full year effect of 1976 and transition quarter actions.....	-68	
Partial year effect in 1977 actions.....	-122	
One less paid day in 1977.....	-36	
Cost of permanent positions in 1977.....		10,144

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
b. Nonpermanent						
Cost	$348	$415	$418	$153	$159	$424
Manyears	50	64	60	24	18	60

The 1977 program includes 60 manyears to support the following programs:

Distribution of Nonpermanent Manyears by Program

	Manyears
College cooperative training	33
Opportunity programs	19
Summer employment	5
Other temporary employment	3
Total	60

The current estimates for 1976 and the Transition Quarter increase from the 1976 budget estimate due to the October 1975 pay raise, partially offset by a reduction in the co-op program. The estimate for 1977 is planned at essentially the same level as 1976 but includes the full year costs of the October 1975 pay raise.

c. Reimbursable detailees	120	132	104	39	26	117

The services of a small group of military officers are utilized in FRC programs where such assignments are of mutual benefit to NASA and the military.

The current estimates for 1976 and the Transition Quarter are decreased from the 1976 budget estimates due to lower ranking officers being assigned for duty, partially offset by the cost of the October 1975 pay raise. The estimate in 1977 reflects the full year effect of the October 1975 pay raise, and additional effort in support of the YF-15 and YF-17 flight research programs.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
d. Overtime and other compensation	89	95	98	24	25	100

The current estimates for 1976 and the Transition Quarter increase from the 1976 budget estimates due to the October 1975 pay raise. The 1977 estimate reflects the full year effect of the October 1975 pay raise.

2. Benefits	888	892	962	233	258	986

The following table indicates the cost of personnel benefits by major categories:

Category of Cost						
Contribution to Civil Service Retirement Fund	668	700	712	182	192	728
Contribution for life insurance	37	34	43	9	11	46
Contribution for employee health insurance	164	138	181	35	46	185
Contribution to FICA	6	8	9	4	4	10
Incentive awards	5	7	7	2	2	7
Other personnel benefits	8	5	10	1	3	10
Total	888	892	962	233	258	986

The current estimates for 1976 and the Transition Quarter increase over the 1976 budget estimate due to the October 1975 pay raise and the higher Government contribuion for employee health and life insurance programs. The 1977 increase provides for the full year cost of the October 1975 pay raise.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
B. Supporting Costs						
1. Transfer of personnel.....	13	10	10	3	3	10
2. Personnel training.....	41	40	40	10	10	40
Total.....	54	50	50	13	13	50

The transfer expenses include movement of household goods for new employees. This estimate provides for the movement of approximately 9 personnel per year.

Personnel training includes the cost for tuition, fees, and related costs for training at colleges, universities, technical institutes, and other institutions. Costs remain essentially level from year to year.

TRAVEL

II. TRAVEL.....	221	242	256	84	84	262

Approximately 60% of Flight's travel funds are utilized in support of the Center's R&D programs, primarily aeronautical research and the Space Shuttle. The increase in cost from the 1976 budget estimate to the current 1976 estimate is attributable to the higher per diem rates authorized in May 1975.

Basis of Fund Requirements
Summary of Travel by Major Category

A. Program Related Travel.....	128	132	151	45	45	157
B. Meetings and Technical Seminars.....	61	84	72	27	27	72
C. Administrative Travel.....	32	26	33	12	12	33
Total, Travel.....	221	242	256	84	84	262

FACILITIES SERVICES

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
III. FACILITIES SERVICES	1,605	1,609	1,745	1,500	1,500	2,735
Basis of Fund Requirements Summary of Facilities Services						
A. Rental of Real Property	---	---	---	---	---	72
B. Maintenance and Related Services						
1. Maintenance of buildings and grounds	838	904	900	896	896	1,230
2. Custodial services	497	413	533	400	400	978
3. Maintenance of equipment	91	90	99	22	22	108
Subtotal, Maintenance and Related Services	1,426	1,407	1,532	1,318	1,318	2,316
C. Operations of Facilities						
1. Utilities	153	164	175	164	164	232
2. Supplies and equipment	26	38	38	18	18	115
Subtotal, Operation of Facilities	179	202	213	182	182	347
Total, Facilities Services	1,605	1,609	1,745	1,500	1,500	2,735

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
A. Rental of Real Property.....	---	---	---	---	---	72

Provides for short term rental of office trailers in 1977 to house personnel at FRC for the Shuttle Approach and Landing Test.

B. Maintenance and Related Services

1. Maintenance of buildings and grounds.....	838	904	900	896	896	1,230

The funding for maintenance of buildings and grounds provides for repair and maintenance of approximately 404,981 square feet of building space located in 23 permanent structures, utility plants and systems, and 511 acres of improved and unimproved grounds.

The current estimate for 1976 shows a slight reduction from the 1976 budget estimate. The increase in 1977 reflects negotiated contractor wage increases and an additional 12 manyears of effort to support shuttle facilities owned by the Air Force, the shuttle hangar, approximately 30 office trailers, and an additional tracking communication facility.

2. Custodial services.....	497	413	533	400	400	978

Included in this category are support contractor services which provide for security, janitorial, refuse handling, fire, and laundry services. The current 1976 estimate increase from the 1976 budget estimate results from negotiated support contractor wage increases over the actual costs experienced in 1975. In 1977, estimates increase because of shuttle support requirements, primarily for security guards (16 manyears) and janitors (7 manyears).

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
3. Maintenance of equipment.....	91	90	99	22	22	108

This estimate is based on maintaining over 300 pieces of office shop laboratory and facilities equipment through a support service contractor and on-call service maintenance contracts. The current estimate for 1976 is increased from the budget estimate to reflect negotiated support service contractor wage increases and equipment maintenance contract price increases. The 1977 increase reflects the full year cost of these rates to maintain the equipment at the same level of serviceability.

C. Operations of Facilities

1. Utilities.....	153	164	175	164	164	232

Electricity and water are obtained from the Air Force and natural gas is obtained from a commercial source. The current estimate for 1976 increases from the 1976 budget estimate due to higher utility rates. The increase in 1977 is due to the full year cost of these higher utility rates and utility consumption increases as a result of the shuttle support requirements.

2. Supplies and equipment.....	26	38	38	18	18	115

The supplies and equipment used to maintain and operate the Center are budgeted in this category. The majority of the items required consist of air conditioning, heating and plumbing materials; hand tools; painting supplies; and hardware items. The increase in 1977 provides for support of Shuttle facilities to be activated in 1977.

TECHNICAL SERVICES

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
IV. TECHNICAL SERVICES	71	76	76	52	52	78
Basis of Fund Requirements						
Summary of Technical Services						
A. Automatic Data Processing						
1. Programming and operations services	16	16	16	16	16	16
B. Engineering Services	2	6	6	2	2	6
C. Scientific and Technical Information and Educational Programs						
1. Operation of NASA scientific and technical libraries	10	12	12	3	3	12
2. Education/information programs	28	28	28	22	22	30
3. Scientific and technical information	15	14	14	9	9	14
Subtotal, Scientific and Technical Information and Educational Programs	53	54	54	34	34	56
Total, Technical Services	71	76	76	52	52	78
A. Automatic Data Processing	16	16	16	16	16	16

Included in this category is contractor keypunch support. Funding for 1977 remains at the same level as 1976.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)					
B. Engineering Services.....	2	6	6	2	2	6

Engineering services are required primarily for drafting and design work which exceed in-house capability and engineering consulting services. This work is performed as required and the cost varies by degree of complexity. Estimates for 1976 and 1977 remain at the same level.

C. Scientific and Technical Information and Educational Programs	53	54	54	34	34	56
1. Operation of NASA technical libraries.....	10	12	12	3	3	12

Books and periodicals for FRC research library are funded from this category. The 1977 budget reflects the continuance of this activity at the current level.

2. Educational/information programs..	28	28	28	22	22	30

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 elementary and secondary levels. The 1977 estimate continues this activity at essentially the same level.

3. Scientific and technical information.....	15	14	14	9	9	14

Funding in this area provides for the procurement of documentation, publication and photographic services. The majority of the funds are used to procure photographic services in excess of in-house capability. Services include processing of 16mm film, contact time prints, color corrected optical masters and various other processing and printing of still and motion picture technical film. The 1977 estimate reflects continuation of the 1976 level of services.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
V. ADMINISTRATIVE SUPPORT.....	446	441	472	268	268	936

Basis of Fund Requirements
Summary of Administrative Support

A. Communications						
1. Leased lines and long distance tolls.....	45	52	55	52	52	61
2. Local telephone service.....	81	62	81	62	62	83
3. Other communications.....	38	3	43	3	3	109
Subtotal, Communications.....	164	117	179	117	117	253
B. Administrative Printing.....	11	20	15	5	5	21
C. Supplies, Materials and Equipment.....	156	186	154	63	63	314
D. Transportation						
1. Center operations.....	89	88	92	68	68	272
2. Common carrier.....	15	20	20	5	5	21
Subtotal, Transportation.....	104	108	112	73	73	293

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)					
E. Administrative Support Services						
1. Installation support services.....	---	---	---	---	7	43
2. Occupational medicine and environmental health.....	11	10	12	10	3	12
Subtotal, Administrative Support Services.....	11	10	12	10	10	55
A. Communications.....	164	117	179	117	117	253

This category provides for Federal Telephone Systems circuits, local telephone services, rental of TWX equipment, and three telephone operators provided under a support service contract.

The current estimate for 1976 increases over the 1976 budget estimate to reflect 1975 experience and rate increases for maintenance, installation and relocation of telephone instruments. The increase in the 1977 estimate is due primarily to additional support required for the Shuttle Program activity.

B. Administrative Printing.....	11	20	15	5	5	21

Administrative printing includes the contractual publication of information and materials, such as the in-house organ and related composition and binding operations. The current estimate for 1976 decreased from the 1976 budget estimate due to the determination to defer printing of certain publications into 1977 to provide for higher costs in other areas. The increase in 1977 provides for those items which were deferred.

C. Supplies, Materials and Equipment.....	156	186	154	63	63	314

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 for administrative support. The lower estimate in 1976 reflects a decrease in purchases to help offset unanticipated increases in other functional areas. The increase in 1977 results from additional requirements to support the Space Shuttle Program and to bring the material and equipment requirements back to the 1976 operating level.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)					
D. Transportation.....	104	108	112	73	73	293

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 and air to fund shipments by United Parcel Service. The increase in 1977 is to support shuttle requirements, including rental and maintenance of approximately 40 vehicles more than in the current inventory.

E. Administrative Support Services.....	11	10	12	10	10	55

This category provides for physical examinations for FRC pilots. In addition, the 1977 estimate provides for general administrative services in support of the Shuttle Program. The increase in 1977 is to provide administrative contractor support to the Space Shuttle Approach and Landing Test team.

FY 1977 Budget Estimates
National Aeronautics and Space Administration
Organization and Staffing Chart
Flight Research Center

SUMMARY STAFFING	CY	BY
Excepted	8	8
GS-16	2	2
GS-15	20	20
GS-14	40	40
All Other GS	425	425
Wage Board	2	2
Total Permanent	497	497

OFFICE OF THE DIRECTOR	CY	BY
Excepted	3	3
GS-16	1	1
GS-15	6	6
GS-14	8	8
All Other GS	36	36
Wage Board	-	-
Total Permanent	54	54

DIRECTOR OF RESEARCH	CY	BY
Excepted	1	1
GS-16	-	-
GS-15	3	3
GS-14	14	14
All Other GS	65	65
Wage Board	-	-
Total Permanent	83	83

DIRECTOR OF FLIGHT OPERATIONS	CY	BY
Excepted	2	2
GS-16	1	1
GS-15	7	7
GS-14	5	5
All Other GS	139	139
Wage Board	-	-
Total Permanent	154	154

DIRECTOR OF DATA SYSTEMS	CY	BY
Excepted	1	1
GS-16	-	-
GS-15	3	3
GS-14	9	9
All Other GS	120	120
Wage Board	-	-
Total Permanent	133	133

DIRECTOR OF ADMINISTRATION AND PROGRAM SUPPORT	CY	BY
Excepted	1	1
GS-16	-	-
GS-15	1	1
GS-14	4	4
All Other GS	65	65
Wage Board	2	2
Total Permanent	73	73

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1977 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 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 Department of Interior. 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, 1975, was $503,363,000.

MISSION

The Langley Research Center is responsible for complex research programs in aeronautics, space science, electronics, and structures, all of which help insure United States leadership in aeronautics and space exploration. Major projects at Langley include management of the Scout and Viking projects; development of aeronautical and space vehicle 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 long haul aircraft, with particular emphasis on fuel conservation, environmental effects, performance, range, safety, and economy. Examples of this research are projects involving a supercritical wing, composite structures and 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.

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 to improve crashworthiness, 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 efficiently in critical environments; practical methods of cooling high-heat areas of aircraft surfaces are being studied; and the technology of hypersonic propulsion is being studied.

Other aeronautical research at Langley focuses on critical problems in acoustics and aircraft noise reduction, alleviation of trailing vortices, increased traction and control of landing gear, and improved physical comfort in aircraft.

Langley has project management responsiblity for NASA's Viking, the recently launched spacecraft that will orbit and land on Mars in 1976. Viking will permit a detailed study of Martian geophysics, atmospheric characteristics, surface properties and, most significantly, experiments that will indicate if life forms are present on the planet.

Langley supports unmanned spacecraft program by the development of experiments and sensors for such missions as Nimbus-G and SEASAT. These programs include the remote sensing of water and air pollution, and the application of space technology to measure various physical phenomena ranging from ocean wave heights to upper atmosheric composition.

Scout launch vehicle procurement is also a long-time Langley responsibility.

Substantial analytical and experimental research is conducted to support the Agency's development of the Space Shuttle and the technologies required for future advanced aerospace transportation systems.

Ground-based research programs at Langley include the investigation of effects on space vehicles of heat, vibration, vacuum, noise, and meteoroids; the development and use of advance composite and polymeric materials to structures and thermal control systems; and improved technology for antennas, advanced microelectric devices, and solid state data recording.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
I. Personnel and Related Costs	73,961	76,036	77,861	19,494	20,426	76,283
II. Travel	2,001	2,267	2,463	681	675	1,952
III. Facilities Services	7,354	7,172	7,145	1,890	1,857	7,960
IV. Technical Services	1,529	1,202	1,504	380	408	1,635
V. Administrative Support	3,797	4,033	3,949	942	953	3,861
Total, fund requirements	88,642	90,710	92,922	23,387	24,319	91,691

Distribution of Permanent Positions by Program

Over three-fourths 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

Space Flight						
Space shuttle	14	---	17	---	17	15
Space flight operations	13	8	8	8	8	1
Expendable launch vehicles	62	62	54	62	54	44

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Space Science						
Physics and astronomy	119	26	52	26	52	13
Lunar and planetary exploration	185	167	168	167	168	58
Space Applications	238	253	229	253	229	245
Aeronautics and Space Technology						
Aeronautical research and technology	1,466	1,499	1,489	1,499	1,489	1,505
Space research and technology	486	585	596	585	596	614
Technology Utilization	16	15	7	15	7	8
Subtotal, direct positions	2,599	2,615	2,620	2,615	2,620	2,503
Indirect Positions						
Director and staff	29	16	29	16	29	29
Administrative support	378	388	383	388	383	383
Research and development support	303	313	298	313	298	257
Subtotal, indirect positions	710	717	710	717	710	669
Total, permanent positions	3,309	3,332	3,330	3,332	3,330	3,172

PERSONNEL AND RELATED COSTS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
I. PERSONNEL AND RELATED COSTS.....	73,961	76,036	77,861	19,494	20,426	76,283
Basis of Fund Requirements						
A. Compensation and Benefits						
1. Compensation						
a. Permanent positions.....	65,929	67,395	69,092	17,169	17,934	67,112
b. Nonpermanent.....	935	1,180	1,029	413	440	1,029
c. Reimbursable detailees.....	9	53	35	13	10	35
d. Overtime and other compensation	533	618	616	155	182	616
Subtotal, Compensation.....	67,406	69,246	70,772	17,750	18,566	68,792
2. Benefits.....	6,047	6,275	6,530	1,615	1,732	6,932
Subtotal, Compensation and Benefits.....	73,453	75,521	77,302	19,365	20,298	75,724
B. Supporting Costs						
1. Transfer of personnel.....	65	96	89	23	25	89
2. Personnel training.....	443	419	470	106	103	470
Subtotal, Supporting Costs....	508	515	559	129	128	559
Total, Personnel and Related Costs.....	73,961	76,036	77,861	19,494	20,426	76,283

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
1. Compensation	67,406	69,246	70,772	17,750	18,566	68,792
a. Permanent positions	65,929	67,395	69,092	17,169	17,934	67,112

The difference betwen the 1976 budget estimate and the current estimate for 1976 is the cost of the October 1975 pay raise. The decrease in 1977 reflects a reduction in manpower from 3,330 to 3,172.

Basis of Cost for Permanent Positions

In 1977 the cost of permanent positions will be $67,112, a decrease of $1,980 from 1976. This decrease results as follows:

Cost of permanent positions in 1976		69,092
Cost increase in 1977		+2,704
Within grade advances and career development:		
Full year effect of 1976 and Transition Quarter actions	+1,120	
Partial year effect of 1977 actions	+790	
Full year effect of October 1975 pay raise	+794	
Cost decrease in 1977		-4,684
Turnover savings:		
Full year effect of 1976 and Transition Quarter actions	-663	
Partial year effect of 1977 actions	-986	
Manpower reduction	-2,760	
One less paid day in 1977	-275	
Cost of permanent positions in 1977		67,112

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
b. Nonpermanent:						
Cost	$935	$1,180	$1,029	$413	$440	$1,029
Manyears	136	170	144	60	59	144

The 1977 program includes 144 manyears to support the following programs:

Distribution of Nonpermanent Manyears by Program

	Manyears
College cooperative training	60
Summer employment	15
Opportunity program	55
Other temporary employment	14
Total	144

The decrease from the 1976 budget estimate to the current estimate is due to refinements in the nonpermanent program based on more current estimates. This is partially offset by the October 1975 pay raise.

c. Reimbursable detailees	9	53	35	13	10	35

The current estimate for 1977 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.

d. Overtime and other compensation	533	618	616	155	182	616

The use of overtime and other compensation is limited to emergency repairs and work that cannot be accomplished during normal working hours. This includes the monitoring of on-site contracts being performed during off-duty hours and wind tunnel work required at night because of power limitations during the normal high peak hours of day. The increase in the transition quarter is due primarily to a more current assessment of the overtime requirements for that period.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Benefits	6,047	6,275	6,530	1,615	1,732	6,932

The distribution of these costs by major categories is as follows:

Category of Cost						
Contribution to the Civil Service Retirement Fund	4,616	4,765	4,878	1,214	1,313	4,746
Contribution for employee life insurance	263	274	320	79	85	320
Contribution for employee health insurance	1,090	1,176	1,250	307	316	1,280
Contribuiton to FICA	22	28	31	7	9	31
Incentive awards	45	30	50	8	9	50
Other personnel benefits	1	2	1	---	---	1
Severence pay	10	---	---	---	---	504
Total	6,047	6,275	6,530	1,615	1,732	6,932

The current estimate for 1976 has increased over the 1976 budget due to the increase in the government's contribution to health benefits and the increased benefits cost associated with the October 1975 pay raise. The increase shown in 1977 is required for the severance pay associated with the reduction of 158 positions.

B. Supporting Costs	508	515	559	129	128	559
1. Transfer of personnel	65	96	89	23	25	89

Transfer of personnel costs include actual expenses involved in the temporary storage of the employees' household goods, subsistence and temporary expenses, real estate costs and miscellaneous moving expenses. Personnel transfers in 1976 are expected to be less than planned in the previous 1976 budget estimate.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Personnel training.....	443	419	470	106	103	470

Training expenses include fees, tuition, and related costs for off-site training and the costs of seminars and workshops. The estimated increase in cost from the 1976 budget estimate to the current estimate reflects increased fees for tuition and related training expenses.

TRAVEL

II.	TRAVEL.....	2,001	2,267	2,463	681	675	1,952

Approximately 75% of Langley's travel requirement is for support of research and engineering programs in the Aeronautics, Space Science, Electronics and Structures disciplines. Also, Langley has project management responsibility for Viking. The landings on Mars are scheduled for 1976.

The current estimate for 1976 is increased over the 1976 budget estimate to reflect the full year effect of the per diem increase.

Travel in FY 1977 reflects the reduced requirement in support of Viking during the science portion of the mission.

Basis of Fund Requirements
Summary of Travel by Major Category

A.	Program Travel.....	1,573	1,874	2,018	587	581	1,465
B.	Meetings and Technical Seminars.....	135	102	120	25	25	130
C.	Administrative Travel.....	293	291	325	69	69	357
	Total, Travel.....	2,001	2,267	2,463	681	675	1,952

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
III. FACILITIES SERVICES.....	7,354	7,172	7,145	1,890	1,857	7,960

Basis of Fund Requirements

Summary of Facilities Services

A. Maintenance and Related Services						
1. Maintenance of buildings and grounds.....	370	795	423	235	55	371
2. Custodial services.....	1,839	1,441	929	375	353	1,468
3. Maintenance of equipment.....	84	74	140	20	37	155
Subtotal.....	2,293	2,310	1,492	630	445	1,994
B. Operation of Facilities						
1. Utilities.....	4,556	3,625	5,439	940	1,351	5,740
2. Supplies and equipment.....	505	1,237	214	320	61	226
Subtotal.....	5,061	4,862	5,653	1,260	1,412	5,966
Total, Facilities Services.....	7,354	7,172	7,145	1,890	1,857	7,960
A. Maintenance and Related Services..	2,293	2,310	1,492	630	445	1,994
1. Maintenance, repair and alterations of buildings and grounds.....	370	795	423	235	55	371

The change from the 1976 and transition quarter budget estimate to the current estimate reflects the necessity to fund unanticipated increases in other areas by decreasing this effort to the 1975 level. The 1977 estimate will fund a minimum level of effort.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Custodial services.....	1,839	1,441	929	375	353	1,468

The change from the 1976 budget to current estimate reflects a reduction of 31 manyears from the 1976 budget, and the minimum obligation required in 1976 in order to provide funds for increased cost rates for utilities and services in other functions above that anticipated in the 1976 budget. The 1977 amount reflects a full year funding for these services at the current level of support.

3. Maintenance of equipment.....	84	74	140	20	37	155

The 1976 current estimate is increased to reflect maintenance on additional equipment purchased in 1975. The 1977 estimate reflects the full year cost of 1976 contractor wage increases.

B. Operation of Facilities.....	5,061	4,862	5,653	1,260	1,412	5,966
1. Utilities.....	4,556	3,625	5,439	940	1,351	5,740

The current estimates for 1976, transition quarter, and 1977 provide for essentially the same level of service as in 1975. The increase in the 1976 current estimate reflects current rates for utilities and the 1977 estimate reflects the full year cost of this higher rate. The current estimates for 1976, transition quarter, and 1977 include fuel oil cost which had previously been carried in the following Supplies and Equipment subfunction category.

2. Supplies and equipment.....	505	1,237	214	320	61	226

The decreases in the current estimates are primarily related to transferring fuel oil costs to the Utilities subfunction. The 1977 estimate reflects the full year cost of price increases.

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TECHNICAL SERVICES

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
IV. TECHNICAL SERVICES.....	1,529	1,202	1,504	380	408	1,635

Basis of Fund Requirements

Summary of Technical Services

A. Automatic Data Processing						
1. Equipment.....	58	119	97	40	35	153
2. Programming and operation services.....	1,017	758	1,064	260	273	1,119
Subtotal.....	1,075	877	1,161	300	308	1,272
B. Scientific and Technical Information and Educational Programs						
1. Library services.....	43	28	48	5	13	52
2. Educational/information programs.....	411	297	295	75	87	311
Subtotal.....	454	325	343	80	100	363
Total, Technical Services.....	1,529	1,202	1,504	380	408	1,635

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)					
A. Automatic Data Processing.....	1,075	877	1,161	300	308	1,272

The current estimate for 1976 reflects the 1975 experience and the impact of contractor wage rate increases which show the budgeted decrease in this function to be unachievable. The increase in 1977 is due to the full year effect of the contractor wage rate increases.

B. Scientific and Technical Information and Educational Programs.....	454	325	343	80	100	363
1. Library services.....	43	28	48	5	13	52

The 1976 current estimate is increased over the previous budget to reflect a level based on current experience. The 1977 estimate is based on the 1976 manyear level and the full year cost of current contract rates.

2. Educational programs.....	411	297	295	75	87	311

The increase in the current estimate for the transition quarter is required to fund additional supply costs due to current price increases. The 1977 estimate reflects a full year effect of these changes.

ADMINISTRATIVE SUPPORT

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
V. ADMINISTRATIVE SUPPORT.....	3,797	4,033	3,949	942	953	3,861

Basis of Fund Requirements

Summary of Administrative Support

A. Communications						
1. Leased lines and long distance tolls.....	330	452	348	113	96	381
2. Local service.....	750	853	826	212	185	800
3. Other communications.....	14	4	15	1	4	16
Subtotal.....	1,094	1,309	1,189	326	285	1,197
B. Administrative Printing.....	3	20	3	5	1	3
C. Supplies, Materials and Equipment...	845	689	741	147	163	673
D. Transportation						
1. Center operations.....	427	629	498	155	133	491
2. Common carrier.....	57	90	81	20	8	30
Subtotal.....	484	719	579	175	141	521
E. Administrative Support Services						
1. Installation support services..	1,158	1,060	1,196	227	302	1,219

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Medical services	213	236	241	62	61	248
Subtotal	1,371	1,296	1,437	289	363	1,467
Total, Administrative Support	3,797	4,033	3,949	942	953	3,861
A. Communications	1,094	1,309	1,189	326	285	1,197

The decrease in the 1976 and transition quarter current estimates reflects actual 1975 experience. The 1977 estimate continues the current level of service with the full year effect of current rates.

B. Administrative Printing	3	20	3	5	1	3

The decrease in the current estimates for 1976 and transition quarter reflects a reduction in administrative contracted printing. The 1977 estimate reflects the same level of service as in 1976.

C. Supplies, Materials and Equipment	845	689	741	147	163	673

The current estimates for 1976 and transition quarter reflect current price increases. The decrease in 1977 is based on a reduction in consumption.

D. Transportation	484	719	579	175	141	521

The decrease in the current estimate for 1976 and transition quarter reflects actual 1975 experience and a decrease in contractor effort. The decrease in 1977 is due to the full year effect of the reduction in services.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
E. Administrative Support Services.....	1,371	1,296	1,437	289	363	1,467

The increase in the current estimate for 1976 and transition quarter is a result of wage increases for contracted services. The 1977 estimate reflects a full year's cost of these increases partially offset by a reduction of six manyears in the contract services.

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1977 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. There are over 100 buildings, including wind tunnels, test chambers, laboratories and other research facilities.

The Plum Brook Station established in 1956, is located south of Sandusky, Ohio, about fifty miles west of Cleveland, on land formerly occupied by the Plum Brook Ordnance works. It occupies 8,051 acres of which 8,004 are owned by the Government and 47 are in easements. There are 122 buildings and 99 concrete storage bunkers. A new 100 KW Electric Wind Turbine Generator Facility designed to be operated remotely has been completed for a program jointly sponsored by the Energy Research and Development Administration and NASA. During the second half of 1975, consistent with our future research and technology needs, the principal facilities were placed in a standby mode.

The total capital investment of the Lewis Research Center including contractor held facilities at various locations as of June 30, 1975, was $420,166,000.

MISSION

Lewis' major responsibility is aeronautical propulsion. 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.

Lewis is also responsible for the management of the Atlas/Centaur and Titan/Centaur launch vehicles. This includes procurement of these vehicles and provision of launch service for missions utilizing them.

The space propulsion programs include chemical and electrical 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 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 nickle 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 responsible for coordinating the launch and mission support.

Lewis energy research efforts includes electric power generation technology which encompasses photovoltaic, electrochemical, and mechanical systems for both space and ground power applications. Ground power generation programs are conducted jointly with the Energy Research and Development Administration (ERDA).

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

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
I. Personnel and Related Costs	69,535	71,833	70,715	18,735	18,663	73,324
II. Travel	983	1,074	1,005	316	316	905
III. Facilities Services	8,022	7,773	8,277	2,538	2,926	9,609
IV. Technical Services	427	406	428	144	144	458
V. Administrative Support	1,347	816	1,286	203	525	1,443
Total, fund requirements	80,314	81,902	81,711	21,936	22,574	85,739

Distribution of Permanent Positions by Program

Over three-fourths 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

Space Flight						
Space flight operations	---	3	---	3	---	---
Expendable launch vehicles	214	213	214	213	214	214
Space Science						
Physics and astronomy	---	---	29	---	29	29
Space Applications	148	106	106	106	106	106

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Aeronautics and Space Technology						
Aeronautical research and technology...	1,352	1,396	1,345	1,396	1,345	1,309
Space research and technology.....	715	711	735	711	735	771
Technology Utilization.....	6	6	6	6	6	6
Subtotal, direct positions.....	2,435	2,435	2,435	2,435	2,435	2,435
Indirect Positions						
Director and Staff.....	7	7	7	7	7	7
Administrative support.....	337	337	337	337	337	337
Research and development support.....	246	246	246	246	246	246
Subtotal, indirect positions.....	590	590	590	590	590	590
Total, permanent positions.....	3,025	3,025	3,025	3,025	3,025	3,025
PERSONNEL AND RELATED COSTS						
I. PERSONNEL AND RELATED COSTS.....	69,535	71,833	70,715	18,735	18,663	73,324
Basis of Fund Requirements						
A. Compensation and Benefits						
1. Compensation						
a. Permanent positions.....	62,009	63,936	63,053	16,658	16,504	65,392
b. Nonpermanent.....	437	622	640	180	277	648

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
c. Overtime and other compensation..	795	940	875	235	241	877
Subtotal, Compensation.....	63,241	65,498	64,568	17,073	17,022	66,917
2. Benefits.....	5,965	6,087	5,888	1,600	1,579	6,148
Subtotal, Compensation and Benefits.....	69,206	71,585	70,456	18,673	18,601	73,065
B. Supporting Costs						
1. Transfer of personnel.....	48	60	34	15	15	34
2. Personnel training.....	281	188	225	47	47	225
Subtotal, Supporting Costs.....	329	248	259	62	62	259
Total, Personnel and Related Costs.....	69,535	71,833	70,715	18,735	18,663	73,324
1. Compensation.....	63,241	65,498	64,570	17,073	17,022	66,917
a. Permanent positions.....	62,009	63,936	63,053	16,658	16,504	65,392

Basis of Cost for Permanent Positions

In 1977 the cost of permanent positions will be $65,392, an increase of $2,339 from 1976. This increase results as follows:

Cost of permanent positions in 1976.....	63,053

Cost increases in 1977		+3,847
Within grade advances and career development		
Full year effect of 1976 and Transition Quarter actions	+1,086	
Partial year effect of 1977 actions	+521	
Full year effect of October 1975 pay raise and wage grade increases	+2,240	
Cost decreases in 1977		-1,508
Turnover savings:		
Full year effect of 1976 and Transition Quarter actions	-800	
Partial year effect of 1977 actions	-439	
One less paid day in 1977	-269	
Cost of permanent positions in 1977		65,392

	1975	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	Budget Estimate
			(Thousands of Dollars)			
b. Nonpermanent:						
Cost	$437	$622	640	$180	277	$648
Manyears	100	104	100	41	47	100

The 1977 program includes 100 manyears to support the following programs:

Programs	Manyears
College cooperative training	35
Summer employment	16
Opportunity program	27
Other employment	22
Total	100

The current estimate for 1976 has been increased from the 1976 budget estimate due primarily to the October pay raise. The number of manyears for 1977 is planned at the same level as 1976.

c. Overtime and other compensation	795	940	875	235	241	877

The current estimate for 1976 reflects savings identified with final phase-down of the Plum Brook Station. The effect of pay increases in 1976 will result in a reduced level of manyears in 1977 in order to maintain a constant cost level.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Benefits	5,965	6,087	5,888	1,600	1,579	6,148

The following table indicates the costs of personnel benefits by major categories:

Category of Cost						
Contribution to Civil Service Retirement Fund	4,341	4,465	4,345	1,181	1,145	4,555
Contribution for life insurance	227	209	273	55	69	275
Contribution for employee health	1,062	1,358	1,198	350	338	1,248
Contribution to FICA	19	25	35	6	14	35
Incentive awards	23	25	30	6	12	30
Other personnel benefits	3	5	5	2	1	5
Severance pay	290	---	2	----	---	---
Total	5,965	6,087	5,888	1,600	1,579	6,148

The 1977 increase provides for the full year cost of the October 1975 pay raise and higher Government contribution for employee health and life insurance programs.

B. Supporting Costs	329	248	259	62	62	259
1. Transfer of personnel	48	60	34	15	15	34

The decrease in the current 1976 transfer of personnel over the 1976 budget reflects the desire for Plum Brook personnel to commute to Cleveland rather than transfer their households.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
2. Personnel training.....	281	188	225	47	47	225

Approximately 40 percent of the training activity supports technically oriented training. Another 35 percent is provided specifically in the scientific and engineering fields. The remaining 25 percent supports administrative and clerical programs. The 1976 current estimate was increased over the 1976 budget estimate to more accurately reflect the increase in training fees and tuition experienced in 1975. The 1976 and 1977 programs reflect a small decrease from the 1975 program in the training activities in order to remain within budgetary restraints.

TRAVEL

II. TRAVEL.....	983	1,074	1,005	316	316	905

Approximately 80 percent of 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 1976 is reduced from the 1976 budget estimate to reflect decreased travel requirements for meetings and administrative travel. Travel requirements for 1977 are estimated at below the 1976 level. This reduction is reflected in program related travel and will be accomplished through increased usage of teleconference equipment.

Basis of Fund Requirements

Summary of Travel by Major Category

A. Program travel.....	810	828	824	244	271	725
B. Meetings and seminars.....	127	171	130	50	30	130
C. Administrative travel.....	46	75	51	22	15	50
Total, Travel.....	983	1,074	1,005	316	316	905

FACILITIES SERVICES

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
III. FACILITIES SERVICES.....	8,022	7,773	8,277	2,538	2,926	9,609

Basis of Fund Requirements

Summary of Facilities Services

A. Maintenance and Related Services						
1. Maintenance, repair and alteration of buildings and grounds.....	874	1,241	722	340	566	621
2. Custodial services.....	1,837	1,711	1,348	573	639	1,881
3. Maintenance of equipment.....	35	107	34	30	9	36
Subtotal.....	2,746	3,059	2,104	943	1,214	2,538
B. Operation of Facilities						
1. Utilities.....	5,164	4,618	6,126	1,565	1,692	6,986
2. Supplies and equipment.....	112	96	47	30	20	85
Subtotal.....	5,276	4,714	6,173	1,595	1,712	7,071
Total, Facilities Services.....	8,022	7,773	8,277	2,538	2,926	9,609

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
A. Maintenance and Related Services....	2,746	3,059	2,104	943	1,214	2,538
1. Maintenance, repair and alteration of buildings and grounds.....	874	1,241	722	340	566	621

During the formulation of the 1976 budget it was assumed that LeRC would return to a normal maintenance and repair program in 1976. Due to budgetary restrictions another delay was required in routine Center maintenance. The current 1976 estimate provides only for emergency repairs with all routine maintenance delayed to the Transition Quarter and 1977. The Transition Quarter estimate of $566 allows for accomplishment of deferred 1976 maintenance and also permits a lower annual maintenance cost rate for 1977.

2. Custodial services.....	1,837	1,711	1,348	573	639	1,881

The change from the 1976 budget to the current estimate reflects a reduction of 20 manyears minimum obligation required in 1976 to provide funds for increased cost rates for utilities and services in other functions above that anticipated in the 1976 budget. The 1977 amount reflects a full year funding for these services at the current wage rates and level of support.

3. Maintenance of equipment.....	35	107	34	30	9	36

The current estimates for 1976 and the Transition Quarter are lower than the 1976 budget to reflect actual 1975 experience.

B. Operation of Facilities	5,276	4,714	6,173	1,595	1,712	7,071
1. Utilities.....	5,164	4,618	6,126	1,565	1,692	6,986

The current estimates for 1976, the Transition Quarter and for 1977 provide for essentially the same level of utility consumption as in 1975. The increase in the current 1976 and Transition Quarter estimates reflect the current rates for utilities and the provision to use coal in lieu of natural gas for heating and steam generation. The 1977 estimate reflects the full year effect of current rates for electricity and coal.

2. Supplies and equipment.....	112	96	47	30	20	85

The current estimate for 1976 decreases from the 1976 budget due to a reduction in the replacement of mechanical shop and general purpose facility equipment which are being deferred to help offset the increased costs

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associated with labor rate increases in support service contracts. The 1977 estimate provides for procurement of some of this deferred equipment.

TECHNICAL SERVICES

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
IV. TECHNICAL SERVICES	427	406	428	144	144	458

Basis of Fund Requirements

Summary of Technical Services

A. Automatic Data Processing						
1. Equipment	171	137	90	27	16	94
2. Programming and operations services	21	40	98	20	25	104
Subtotal	192	177	188	47	41	198
B. Engineering Services	41	90	33	26	32	35
C. Scientific and Technical Informational and Educational Programs						
1. Technical libraries	22	---	25	---	6	25
2. Educational/information programs	143	121	164	59	59	180
3. Scientific and technical information	29	18	18	12	6	20
Subtotal	194	139	207	71	71	225
Total, Technical Services	427	406	428	144	144	458
A. Automatic Data Processing	192	177	188	47	41	198

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The current estimates are the net change of decreased rental costs due to the purchase of an Ampex core and the increased maintenance costs associated with the conversion from a UNIVAC 1110 to an 1140 System. It also includes the costs of an in-house support service contractor for business data key punching which was initiated late in 1975.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
B. Engineering Services	41	90	33	26	32	35

The current estimates for 1976 and for 1977 are below the 1976 budget estimate due to the completion of the standby condition of the Plum Brook Station.

C. Scientific and Technical Information and Educational Programs	194	139	207	71	71	225

The current estimate for 1976 reflects a labor rate increase for the support service contract in this area as well as increased exhibit displays associated with the Lewis Visitor Center. The 1977 estimate provides for the full year cost of the increased rates.

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ADMINISTRATIVE SUPPORT

V. ADMINISTRATIVE SUPPORT	1,347	816	1,286	203	525	1,443

Basis of Fund Requirements

Summary of Administrative Support

A. Communications						
1. Leased lines and long distance calls	272	338	312	86	80	335
2. Local telephone service	217	225	193	55	50	210
3. Other communications	30	49	48	12	14	52
Subtotal	519	612	553	153	144	597

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
B. Administrative Printing.....	62	30	63	3	16	68
C. Supplies, Materials, and Equipment...	136	79	107	10	47	125
D. Transportation						
1. Center operations.....	107	29	101	6	60	108
2. Common carrier.....	36	7	30	2	10	30
Subtotal.....	143	36	131	8	70	138
E. Administrative Support Services						
1. Installation support.....	442	6	387	6	236	470
2. Occupational medicine and environmental health.....	45	53	45	23	12	45
Subtotal.....	487	59	432	29	248	515
Total, Administrative Support.....	1,347	816	1,286	203	525	1,443
A. Communications.....	519	612	553	153	144	597

Included in this function are local telephone service and FTS leased lines, as well as teletype service.

The current estimate for 1976 has decreased from the 1976 budget due to the standby condition of the Plum Brook Station and the decrease of FTS costs at that location, partially offset by rate increases in 1976.

1977 estimates will continue at the 1976 level with a slight increase in communications due to the full year effect of 1976 rate increase.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
B. Administrative Printing.....	62	30	63	3	16	68

The 1976 and Transition Quarter current estimates are increased over the budget estimate based on 1975 experience. The 1977 estimate provides the same service as in 1976 but allows for full year effect of rate increases.

C. Supplies, Materials and Equipment.....	136	79	107	10	47	125

The increases in the 1976 current estimate and the Transition Quarter current estimate over the 1976 budget estimate reflect costs based on 1975 actual experience where anticipated reductions in 1976 are not fully achieveable. 1977 continues at the 1976 level with an increase
and equipment.

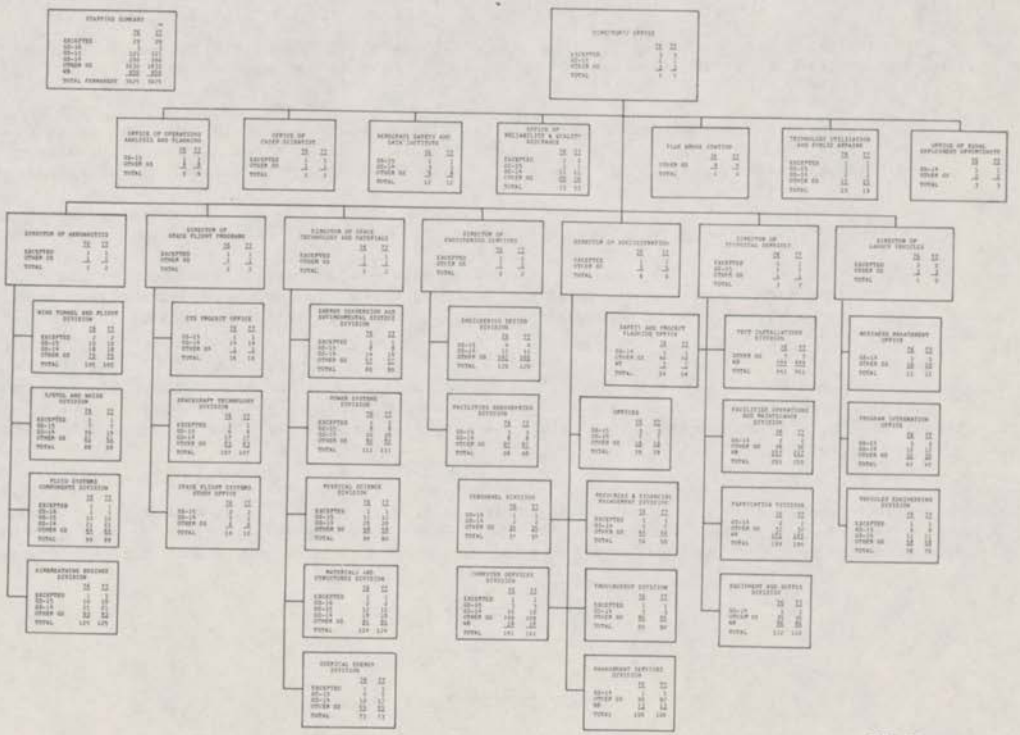
D. Transportation.....	143	36	131	8	70	138

The increase of the current 1976 and Transition Quarter estimates over the 1976 budget reflect 1975 experience and increased wage rates on the vehicle maintenance contract. The 1977 estimate provides the same level of service but allows for the full year effect of the rate increases.

E. Administrative Support Services.....	487	59	432	29	248	515

The increase in the 1976 current estimate over the budget estimate allows for continuation of the Plum Brook Station property identification and control effort associated with the placement of the facility in a standby condition. Emphasis on this effort was not anticipated in the 1976 budget. The increases in the Transition Quarter and in 1977 reflect the phasing needed to complete the property identification and control effort by the end of 1977.

National Aeronautics and Space Administration
Organization and Staffing Chart
LEWIS RESEARCH CENTER
Cleveland, Ohio



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RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1977 ESTIMATES

NASA HEADQUARTERS

DESCRIPTION

NASA Headquarters is located at 400 Maryland Avenue, SW, Washington, DC, and also occupies other buildings in the District of Columbia and nearby Virginia. Except for some office space leased in the District of Columbia and a storage area in Virginia, personnel 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 Space Flight - Responsible for the research, development, and operations of space flight programs including 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 acquired by the Department of Defense to be followed later in the 1980's by a Space Tug. A recent organizational realignment transferred program responsibility for expendable launch vehicles to this office.

Office of Space Science - Responsible for scientific research and development effort utilizing a variety of flight system and ground-based observations to increase man's knowledge of the universe. The Earth, Sun, Moon, interplanetary space, solar systems, other stars and galaxies, and the interaction among these bodies and systems are all objects of these investigations. A recent organizational realignment transferred responsibility for space life sciences to this office.

Office of Applications - Responsible for research and development activities leading to programs providing beneficial applications of space systems, the earth environment, and space related or derived technology. Programs involved include earth observation, meteorology, geodesy, and related disciplines; use of the space environment for materials, sciences and processing; and the application of space developed technology to 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 and which may have general application to the nation's aeronautical and space objectives. This office is also responsible for coordinating the Agency's total program of supporting research and technology related to carrying our 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, command, communications, and data processing facilities, systems and services required for support of all NASA flight missions. This office also provides centralized planning and systems management for the administrative communications of NASA installations.

Office of Energy Programs - Responsible for coordinating NASA support of other Federal Agencies conducting energy research and development; and, managing NASA effort applying aeronautics and space technology to the generation, transmission, storage, conservation, utilization, and management of energy in non-aerospace applications.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
I. Personnel and Related Costs.....	45,119	45,781	47,094	13,683	14,228	48,599
II. Travel.....	2,226	2,465	2,458	701	701	2,458
III. Facilities Services.....	3,508	4,105	3,790	1,100	982	4,379
IV. Technical Services.....	10,708	10,561	10,503	2,786	2,786	11,682
V. Administrative Support.....	7,304	6,581	9,908	1,754	1,782	7,451
Total, fund requirements.....	68,865	69,493	73,753	20,024	20,479	74,569

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:

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
Direct Positions						
Space Flight						
Shuttle	77	80	77	80	77	77
Space flight operations	101	105	101	105	101	101
Expendable launch vehicles	18	19	18	19	18	18
Space Science						
Physics and astronomy	36	56	36	56	36	36
Lunar and planetary exploration	48	37	48	37	48	48
Life sciences	20	20	20	20	20	20
Applications	97	97	97	97	97	97
Aeronautics and Space Technology						
Aeronautical research and technology	81	76	81	76	81	81
Space research and technology	80	71	80	71	80	80
Tracking and Data Acquisition	42	45	42	45	42	42
Technology Utilization	19	18	19	18	19	19
Subtotal, Direct Positions	619	624	619	624	619	619

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Indirect Positions						
Administrator and staff	169	163	169	163	169	169
Agency-wide management	591	591	591	591	591	573
Headquarters Administration	192	192	192	192	192	192
Subtotal Indirect Positions	952	946	952	946	952	934
Total, permanent positions	1,571	1,570	1,571	1,570	1,571	1,553
PERSONNEL AND RELATED COSTS						
I. PERSONNEL AND RELATED COSTS	45,119	45,781	47,094	13,683	14,228	48,599
Basis of Fund Requirements						
A. Compensation and Benefits:						
1. Compensation:						
a. Permanent positions	38,414	38,393	39,483	9,714	10,132	40,461
b. Nonpermanent	1,135	726	1,002	242	319	1,022
c. Reimbursable detailees	223	385	284	96	103	289
d. Overtime and other compensation	164	239	212	60	64	216
Subtotal, compensation	39,936	39,743	40,981	10,112	10,618	41,988
2. Benefits:	4,580	5,271	5,390	3,295	3,334	5,888
Subtotal, compensation and benefits	44,516	45,014	46,371	13,407	13,952	47,876

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
B. Supporting Costs:						
1. Transfer of personnel.....	159	280	240	90	90	240
2. Civil Service Commission Services.....	90	136	132	36	36	132
3. Personnel training.....	354	351	351	150	150	351
Subtotal, supporting costs....	603	767	723	276	276	723
Total Personnel and Related Costs.....	45,119	45,781	47,094	13,683	14,228	48,599
1. Compensation:	39,936	39,743	40,981	10,112	10,618	41,988
a. Permanent positions.....	38,414	38,393	39,483	9,714	10,132	40,461

The cost for permanent positions is the largest part of the personnel and related costs. The funds shown above will support 1,553 permanent positions in 1977, a reduction of 18 from the 1976 level.

Basis of Cost for Permanent Positions
(Thousands of Dollars)

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 and abolishment of existing positions, within grade advances, career development, and the October 1975 pay increase. After these modifications, the year-end position structure is established and the cost effect for the year is calculated based on the estimated period that these modifications are in effect:

Cost of permanent positions in 1976.....	39,483
Cost of increases in 1977.....	+1,516
Within grade advances and career development:	
Full year effect of 1976 and transition quarter actions.....	+550

Partial year effect of 1977 actions	+434	
Full year effect of October 1975 pay raise	+532	
Cost decreases in 1977		-538
Turnover savings		
Full year effect of 1976 and transition quarter actions	-194	
Partial year effect of 1977 actions	-123	
One less paid day in 1977	-141	
Partial year effect of 1977 manpower reduction	-80	
Cost of permanent positions in 1977		40,461

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
b. Nonpermanent						
Cost	$1,135	$726	$1,002	$242	$319	$1,022
Manyears	114	87	101	29	39	101

Distribution of Nonpermanent Manyears by Program

	Manyears
College cooperative training	12
Summer employment	19
Opportunity programs	47
Other temporary employment	23
Total	101

The increase in the 1976 current estimate over the 1976 budget estimate is due to increase in Co-op and Opportunity programs, an increase in the number of temporary personnel consistent with requirements for support for short term periods, and the cost of the October 1975 pay raise. The increase in 1977 reflects the full year's cost of the pay raise.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
c. Reimbursable detailees.....	223	385	284	96	103	289

The current estimate for 1976 is decreased from the 1976 budget estimate due to a reduction in the number of detailees planned at Headquarters. The resulting savings is partially offset by the cost of the October 1975 pay raise. The increase in 1977 reflects the full year cost of the pay raise.

d. Overtime and other compensation...	164	239	212	60	64	216

The reduction in 1976 from the budget estimate reflects identified requirements based on 1975 usage partly offset by the cost of the October 1975 pay raise. The 1977 estimate reflects the full year cost of the pay increase.

2. Benefits:	4,580	5,271	5,390	3,295	3,334	5,888

The following table indicates the cost of personnel benefits by the major categories:

Category of Cost						
Civil Service Retirement Fund.	2,663	2,661	2,756	693	717	2,829
Employees life insurance.....	149	139	178	35	38	182
Employee health insurance.....	465	577	523	126	141	535
FICA.....	48	44	60	15	12	61
Incentive awards.....	74	53	76	13	13	76
Workmen's compensation.....	1,181	1,797	1,797	2,413	2,413	2,205
Total.....	4,580	5,271	5,390	3,295	3,334	5,888

The increase in 1976 and the Transition Quarter over the 1976 budget estimate is mainly attributable to the October 1975 pay increase. The increase in 1977 over the 1976 current estimate is due primarily to the higher cost for workman's compensation, which Headquarters pays for the entire agency, and the full year costs of the October 1975 pay increase.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
B. Supporting costs.....	603	767	723	276	276	723

Supporting Personnel Costs provide for the expense of moving employees to 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.....	159	280	240	90	90	240

This provides primarily for the moving costs associated with the relocation of personnel. The decrease in the 1976 current estimate over the 1976 budget estimate is due to a reduction in the estimated number of new hires.

2. Civil Service Commission Services.....	90	136	132	36	36	132

Headquarters reimburses the Civil Service Commission and others for investigation of new hires and Equal Employment Opportunity (EEO) investigations. The cost of investigations is a function of two variables, the number of investigations to be conducted and the unit charge made by the Civil Service Commission or other agency. There is also a payment to the Commission for federal usage system surveys and any requested investigation of formal discrimination complaints.

3. Personnel Training.....	354	351	351	150	150	351

The maintenance and expansion of the skills of personnel is essential in carrying out the agency's many complex technical programs. Such training is provided within the framework of the Government Employees Training Act of 1958. Part of the training consists of courses offered by other Government agencies, usually for a fee. The remainder of the training is provided through nongovernmental sources. The cost is for tuition, fees and related costs for training at colleges, universities, technical institutions; and for the cost of seminars and workshops in which groups of Headquarters and Field Center employees receive training in subjects of agency-wide interest.

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TRAVEL

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
II. TRAVEL	2,226	2,465	2,458	701	701	2,458

Travel funds are used in direct support of NASA's research and development programs, such as Space Shuttle and the Viking mission to Mars, by members of research advisory committees, and by NASA officials to national and international conferences and working panels and travel to the NASA field installations to review requirements and operations to assure agency policies and procedures are being implemented properly throughout the agency.

The current estimate for 1976 has been adjusted to reflect 1975 experience and to cover the cost of the higher per diem rates, effective in May 1975.

Basis of Fund Requirements

Summary of Travel by Major Category

A. Program Travel	757	925	862	270	252	862
B. Meetings and Technical Seminars	678	771	772	223	226	772
C. Administrative Travel	791	769	824	208	223	824
Total, travel	2,226	2,465	2,458	701	701	2,458

FACILITIES SERVICES

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
III. FACILITIES SERVICES.....	3,508	4,105	3,790	1,100	982	4,379

Basis of Fund Requirements

Summary of Facilities Services

A. Rental of Real Property.....	3,025	3,643	3,268	983	865	3,824
B. Maintenance and Related Services						
1. Maintenance of buildings and grounds.....	330	300	340	75	75	340
2. Custodial services.....	143	155	175	40	40	205
3. Maintenance of equipment.....	3	3	3	1	1	6
Subtotal, Maintenance and Related Services.....	476	458	518	116	116	551
C. Operation of Facilities	7	4	4	1	1	4
Total, Facilities Services.....	3,508	4,105	3,790	1,100	982	4,379

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
A. Rental of Real Property.....	3,025	3,643	3,268	983	865	3,824

Public Law 92-313 requires that agencies reimburse the General Services Administration (GSA), at approximate commercial equivalent rates, for space and related services provided. The current estimate for 1976 is decreased from the budget estimate to reflect a 10% cut in GSA rental charges specified in the FY 1976 Appropriation Act. The estimate for 1977 reflects the full amount of charges for rental from GSA. Also included are facilities used by NASA Pasadena Office. Funds provide for the lease of hangar, shop, and office space at Hollywood Burbank Airport required for NASA-7, a NASA-owned JPL-operated fixed wing aircraft.

B. Maintenance and Related Services.....	476	458	518	116	116	551
1. Maintenance of Buildings and Grounds.....	330	300	340	75	75	340

This estimate includes alterations such as partition changes, telephone changes and general buildings' maintenance. The current estimate for 1976 reflects 1975 experience and the higher labor cost rates for these services. The 1977 estimate continues the 1976 level of service.

2. Custodial Services.....	143	155	175	40	40	205

This estimate covers security guard service in the various Headquarters buildings. The increase in the 1976 current estimate reflects one additional guard and two additional guards in 1977 to help counteract the increasing amount of theft and pilferage experienced in Headquarters offices.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
3. Maintenance of Equipment.....	3	3	3	1	1	6

This category includes reimbursement to GSA for the installation and maintenance of the security alarm systems and equipment in the NASA Headquarters buildings. The increase in 1977 is attributable to the purchase of technical security equipment to provide counter-measures against theft and electronic penetration of NASA Headquarters.

C. Operation of Facilities.....	7	4	4	1	1	4

Provides replacement of medical equipment required for the operation of the Headquarters Occupational Medicine and Environmental Health Unit.

TECHNICAL SERVICES

IV. TECHNICAL SERVICES.....	10,708	10,561	10,503	2,786	2,786	11,682

Basis of Fund Requirements

Summary of Technical Services

A. Automatic Data Processing						
1. Equipment.....	1,076	1,354	1,738	336	336	1,850
2. Programming and operation services.....	2,013	1,811	1,587	455	455	2,018
Subtotal.....	3,089	3,165	3,325	791	791	3,868

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
B. Engineering Services.....	10	140	140	36	36	179
C. Scientific and Technical Information and Educational Programs						
1. Operation of NASA technical libraries.....	53	56	98	16	16	116
2. Educational/informational programs.....	2,325	1,835	1,866	484	484	1,992
3. Scientific and technical information.....	5,231	5,365	5,074	1,459	1,459	5,527
Subtotal.....	7,609	7,256	7,038	1,959	1,959	7,635
Total, Technical Services.....	10,708	10,561	10,503	2,786	2,786	11,682
A. Automatic Data Processing.....	3,089	3,165	3,325	791	791	3,868

This category provides for the lease, purchase, maintenance, and programming and operations services of ADP equipment other than equipment dedicated to specific research or operational systems which is funded from the Research and Development appropriation. The increase in 1976 over the budget estimate is principally to provide for the reconfiguration of the computer support to the NASA scientific and technical information programs. Also reflected are higher lease costs for the computer system supporting Headquarters data processing. The increase in 1977 reflects the full year cost of these actions.

B. Engineering Services.....	10	140	140	36	36	179

This will provide for the preparation of a study of failure and mishap data to focus on prevention and costs; reliability cost evaluation study; Health Act compliance; and NASA-wide Safety, Reliability and Quality Assurance Standards. The increase in 1977 will provide a study to evaluate failure experience with the aim of establishing cost estimating guidelines for various levels of reliability.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
C. Scientific and Technical Information and Educational Programs	7,609	7,256	7,038	1,959	1,959	7,635

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	53	56	98	16	16	116

Technical libraries provide information in support of NASA scientists, engineers, administrators, and managers. The increase in 1976 over the budget estimate provides for implementation of a computerized library system to enhance the potential for sharing library resources among the NASA installations. The increase in 1977 provides for the modest expansion of this system and for the higher subscription rates for periodicals and other publications.

2. Educational/Informational Programs	2,325	1,835	1,866	484	484	1,992

The educational/informational programs provide for the gathering and dissemination of information about the agency's programs to the mass communications media, the general public, and to the educational community at the elementary and secondary levels. Assistance to the mass communications media includes the gathering and exposition of newsworthy materials in support of their requests, and takes such forms as press kits, new releases, television and radio information tapes and clips, and feature material.

Research, development, and operational missions in aeronautics and space provide substantial knowledge and serve as an educational stimulus to students and teachers. NASA responds to expressed needs of students and teachers by developing curriculum supplements in space-related areas such as physics, biology, chemistry, and math; assistance to over 1,000 teacher workshops and professional education meetings (with over 30,000 teachers participating) and participation in science fairs. The largest single program is the Spacemobile, a touring space-science education lecture demonstration unit. These funds also provide for EEO exhibits and EEO films to relate to high schools, colleges, and the public the key roles that women and minorities play in the U. S. Space Program.

The small increases in 1976 and 1977 over the 1976 budget estimate provide for higher contractor wage rates reflected in the Spacemobile operations contract effective in 1976.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
3. Scientific and Technical Information	5,231	5,365	5,074	1,459	1,459	5,527

The scientific and technical information activity includes the cost of the NASA Scientific and Technical Information Facility, documentation and publication services, systems development, and translation services. The largest requirement is the NASA Scientific and Technical Information Facility, which will cost $3.4 million in 1977. These costs are for the documentation of worldwide aerospace journal and report literature; monographs and technical reviews; analyzing, evaluating, and testing new methods and systems in the field of scientific communications to increase the effectiveness of the technical information program; and translating foreign language technical books, reports, and journal articles required to meet the needs of NASA and its contractor scientific personnel to keep abreast of world developments in the space sciences and related fields. The decrease in 1976 from the budget estimate reflects reduced effort in several areas to allow reprogramming of funds to procure the additional ADP equipment discussed above. The increase over the 1976 estimate is the result of the need to provide a full 12 months funding in 1977 at current wage rates.

ADMINISTRATIVE SUPPORT

V. ADMINISTRATIVE SUPPORT	7,304	6,581	9,908	1,754	1,782	7,451

Basis of Fund Requirements

Summary of Administrative Support

A. Communications						
1. Leased lines and long distance tolls	550	561	570	142	142	572
2. Local telephone service	428	400	572	100	100	585
3. Other Communications	1,903	2,243	2,121	618	618	2,126
Subtotal	2,881	3,204	3,263	860	860	3,283

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
B. Administrative Printing	436	405	437	102	102	446
C. Supplies, Materials, and Equipment	1,401	877	914	230	258	982
D. Transportation						
1. Center operations	166	126	3,241	32	32	161
2. Common carrier	30	25	25	5	5	29
Subtotal	196	151	3,266	37	37	190
E. Administrative Support Services						
1. Installation support services	2,208	1,741	1,825	472	472	2,342
2. Medical services	182	203	203	53	53	208
Subtotal	2,390	1,944	2,028	525	525	2,550
Total, Administrative Support	7,304	6,581	9,908	1,754	1,782	7,451
A. Communications	2,881	3,204	3,263	860	860	3,283

Included in this estimate are the costs of leased lines, long distance tolls, telephone exhange services, and other communications, such as TWX and postage (Headquarters pays for the agency's postage). The increase in 1976 over the budget estimate reflects higher rates for local telephone service provided by GSA, partially offset by a decrease in the postage costs resulting from the newly established Express Mail Service rates.

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)					
B. Administrative Printing.....	436	405	437	102	102	446

Estimates for administrative printing include funds for contractual printing and the related composition and binding operations performed by other agencies, chiefly the Government Printing Office, or by commercial printing firms. All common processes of duplicating including photostating, blueprinting, microfilming, and other photographic reproductions, are included. The increase in 1976 over the budget estimate is the result of higher labor and material cost than planned. The slight increase in 1977 is a result of the full year cost of the increases in 1976.

C. Supplies, Materials and Equipment	1,401	877	914	230	258	982

Administrative supplies, materials, and equipment include those items of a general nature which service the entire Headquarters. Of the amount estimated for 1977, $388 is for supplies and materials, and $594 for purchased and rented equipment. The increase in 1976 over the budget estimate reflects higher prices for office supplies than planned in the 1976 budget. The increase in 1977 provides for acquisition of word processing equipment.

D. Transportation.....	196	151	3,266	37	37	190

Transportation services include rental of trucks, as well as the movement of supplies, materials, equipment and related items. The increase in 1976 over the budget estimate is principally to provide for the replacement of an administrative aircraft. The 1977 estimate reflects a return to the 1975 funding level.

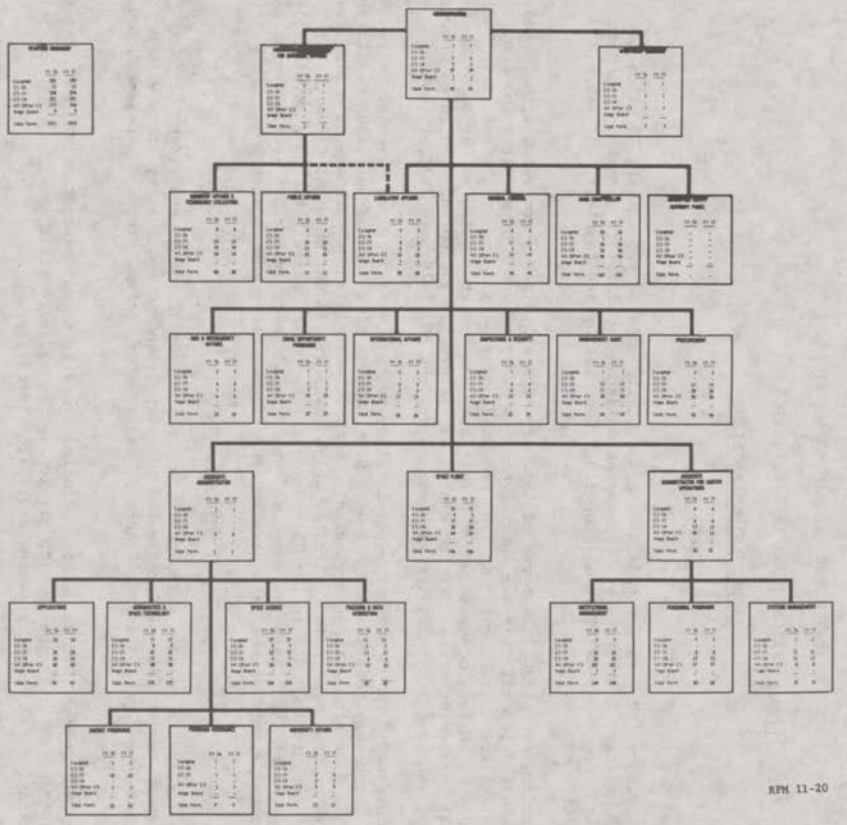
E. Administrative Support.....	2,390	1,944	2,028	525	525	2,550

Administrative support services include those services which support the Headquarters generally, such as: chart and related art work, operation of photocopy equipment, maintenance and repair of office equipment and vehicles, motion picture services, minor government services, contract histories, special economic studies, trucking and laboring services, medical services, patent services, international support services, contractor incentive awards, EEO community relations and fellowships, administrator representation allowance, NASA management training facility study, overseas administrative support, documentation and related services. The increase in 1976 from the budget estimate is due primarily to wage incresases in the copy machine oper-

ations contract renegotiated in 1976, higher than estimated cost of NASA's share of the CSC Information Center, and the increased cost of overseas administrative support as billed by the Department of State. Increases in 1977 provide for special economic studies and task type contracts for quick reaction technical analyses and programmatic assessments.

ORGANIZATION AND STAFFING

NASA HEADQUARTERS



RPM 11-20

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1977 ESTIMATES

JET PROPULSION LABORATORY

DESCRIPTION

The Jet Propulsion Laboratory (JPL) is located in Pasadena, California, approximately 20 miles north of downtown Los Angeles. Subsidiary facilities are located at Goldstone, California (tracking and data acquisition), Edwards Air Force Base, California (propellant formulation and testing), and Table Mountain, California (open air testing and astronomy).

At Pasadena, the Laboratory occupies 176.8 acres of land of which 145.9 acres are owned by NASA and 30.9 acres are leased. At Goldstone, facilities are located on land occupied under permit from the Army. At Edwards Air Force Base, facilities are located on land occupied under permit from the Air Force. Facilities at Table Mountain are located on land occupied under permit from the Forest Service of the Department of Agriculture. The capital investment of the Jet Propulsion Laboratory, including the Deep Space Network, fixed assets in progress, and contractor-held facilities, as of June 30, 1975, was $373,913,000.

The Jet Propulsion Laboratory is a Government-owned facility managed, staffed, and operated by the California Institute of Technology under a contract with NASA. The entire cost of operating the Laboratory is borne by the Research and Development appropriation, except for the lease or purchase of administrative aircraft and the purchase of passenger motor vehicles, which costs are funded from the Research and Program Management appropriation and are included in the NASA Headquarters budget presentation. Accordingly, the Research and Program Management type costs presented in this Special Analysis for JPL are for purposes of comparison only, and are not a part of the NASA Research and Program Management budget.

MISSION

The Jet Propulsion Laboratory is engaged principally in research, development, and flight project activities concerned 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 spaceflight 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. The development and operation of the Deep Space Network which provides tracking and data acquisition services for all NASA projects involving flights of automated spacecraft beyond near-earth orbits.

3. A continuing program of supporting research and technology.

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 recently launched missions in the Mariner series are those of Mariners 9 and 10. 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 1/2 - 4 years. Scientific data will be gathered on the interplanetary medium, the planets themselves, several of the large satellites of the planets, and the rings of Saturn. These missions and objectives have been endorsed by the Space Science Board of the National Academy of Sciences as an appropriate next step in planetary exploration. The spacecraft design for these missions will make maximum use of previous Mariner and Viking Orbiter designs and technology, consistent with the requirements of long-range communications, solar independent power, and the required flight times.

The Laboratory is also involved as a major participant in the Viking project which involves two flights to Mars launched during August and September 1975. Each flight employs a spacecraft consisting of an orbiter and a lander. 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. The entire spacecraft will be placed in orbit about Mars, and after suitable preparations the lander will separate from the orbiter to enter the Martian atmosphere and soft land on the surface of the planet. Scientific data will be collected in orbit, during atmospheric entry, and on the surface. In addition to delivery of the lander, the primary functions of the orbiter are to provide current observational data for use in final selection of the landing site, and to serve as a relay station to receive, store, and retransmit to earth data obtained from the lander. The orbiter will conduct its own science experiments, including television pictures of the Martian surface, infrared radiometry to determine surface temperatures, infrared spectrometry to detect water vapor, and radio propogation experiments to improve planetary navigation capabilities and provide measurements of properties of the Mars atmosphere.

Space Applications - The Jet Propulsion Laboratory is responsible for project management of the Ocean Dynamics Satellite (SEASAT-A), which is scheduled for launch in 1978. The objectives of SEASAT-A are to demonstrate a capability to measure global ocean dynamics and physical characteristics, demonstrate the

economic and social benefits to be added to user organization products and services by such a monitoring system, and improve the body of scientific data now utilized by geodesists and tectonic physicists.

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 the planetary sciences, physics and astronomy, and earth and ocean physics. These activities involve broad collaboration with the scientific and academic communities and with staff members from other NASA field installations.

Tracking and Data Acquisition - The Jet Propulsion Laboratory is responsible for the design, development, maintenance, and operation of NASA's world-wide Deep Space Network and a Mission Control and Computing Center. Tracking stations are located in California, Spain, and Australia. These facilities provide support not only to JPL-managed flight missions, but also to projects such as Pioneer and Helios managed by other NASA installations and involving flights beyond near-earth orbits.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDS

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
I. Personnel and Related Costs.....	84,310	90,648	92,971	24,508	27,232	98,066
II. Travel.....	3,490	3,089	3,477	927	940	3,417
III. Facilities Services.....	7,626	7,982	8,210	2,135	2,320	8,877
IV. Technical Services.....	2,177	2,210	2,460	591	597	2,435
V. Administrative Support.....	8,395	9,099	9,762	2,434	2,472	9,798
Total, fund requirements.....	105,998	113,028	116,880	30,595	33,561	122,593

Distribution of Permanent Manyears by Program

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
	(Average Number)					
Direct Manyears						
Space Flight						
Space shuttle	10	9	10	9	8	14
Space flight operations	5	---	---	---	---	---
Expendable launch vehicles	3	4	1	4	4	5
Space Science						
Physics and astronomy	32	16	40	16	44	37
Lunar and planetary exploration	1,075	1,027	990	1,027	976	980
Life sciences	4	5	4	5	4	4
Space Applications	114	139	183	139	184	181
Advanced Research and Technology						
Aeronautical research and technology	14	14	12	14	12	17
Space research and technology	249	257	256	257	260	251
Tracking and Data Acquisition	336	350	348	350	348	345
Technology Utilization	6	10	9	10	8	12
Subtotal, direct manyears	1,823	1,831	1,853	1,831	1,848	1,798
Direct Support	621	622	618	622	620	607
Indirect Manyears	1,187	1,203	1,185	1,203	1,188	1,146
Total, manyears	3,656	3,656	3,656	3,656	3,656	3,551

Simulated Research and Program Management Budget

Explanation of Changes

Personnel and Related Costs - The increase in the 1976 current estimate over the 1976 budget estimate, and the increase in the 1977 estimate are a result of cost of living and merit increases for permanent and nonpermanent personnel. Personnel benefits changed as a result of higher costs in the retirement plans, an increase in the FICA base, and an increase in health insurance rates. surance rates.

Travel - The increase in the 1976 current estimate over the 1976 budget estimate is a result of higher airline fares, per diem and lodging costs as well as increased program travel. The change in 1977 reflects the impact of travel cost increases offset by decreased travel activity.

Facility Services - The increase in the 1976 current estimate over the 1976 budget estimate and the increase in the 1977 estimate are a result of higher utility costs, price increases for supplies and equipment, and wage increases for maintenance and related services.

Technical Services - The increase from the 1976 budget estimate to the 1976 current estimate is due mainly to higher than anticipated ADP programming and operation, and engineering services for installation energy reduction studies, partially offset by a reduction in scientific information program activity. The change from 1976 to 1977 is mainly due to higher costs for engineering services in data management and fabrication, electronic parts, and technical documentation services, offset by decreased consumption.

Administrative Services - The change from the 1976 budget to the 1976 current estimate is due mainly to the increase in Caltech overhead and fee. The change from 1976 to 1977 is mainly due to higher rates for long distance and local exchange services and increases in the areas of printing and reproduction offset by a reduction in supplies, materials and equipment.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1977 ESTIMATES

SUMMARY OF AERONAUTICAL RESEARCH AND TECHNOLOGY
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Millions of Dollars)			
Research and development.....	$166.4	$175.4	$175.4	$46.8	$43.8	$189.1
Construction of facilities.....	9.7	4.6	4.6	---	---	29.0
Research and program management....	137.7	134.2	143.2	37.0	35.7	146.2
Total.....	$313.8	$314.2	$323.2	$83.8	$79.5	$364.3
Number of direct positions (end of year) associated with aeronautical research and technology.	3,824	3,849	3,841	3,849	3,845	3,799

The Aeronautics program for FY 1977 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 1977 to provide the solid technology base necessary to stimulate and meet the future requirements of civil aviation. Special emphasis will be given to increasing aircraft energy efficiency and reducing 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; and the reduction of aerodynamic drag. 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 advanced 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 1977 includes funding for a modification of the flight simulator for advanced aircraft at the Ames Research Center, the construction of an addition for the aeroelastic model laboratory at the Langley Research Center, and for rehabilitation of the combustion air drying system for the engine research building at the Lewis Research Center. It also provides for the first annual funding increment for the construction of the national transonic facility at the Langley 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 1977 OBLIGATIONS FOR
EQUIPMENT TO BE PLACED AT NASA INSTALLATIONS

Program Budget Line Item	(Thousands of Dollars) 1977
Space Flight	$111,040
Space Shuttle	(100,034)
Space Flight Operations	(7,563)
Expendable Launch Vehicles	(3,443)
Space Science	1,771
Physics and Astronomy	(738)
Lunar and Planetary Exploration	(863)
Life Sciences	(170)
Space Applications	1,184
Aeronautics and Space Technology	27,300
Aeronautical Research and Technology	(21,950)
Space Research and Technology	(5,350)
Tracking and Data Acquisition	10,800
GRAND TOTAL	152,095

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SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN FY 1977 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION, BUILDING LOCATION, AND EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	FY 1977 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.	1,100	
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.	500	Facility modifications are included in the FY 1976 C of F project 7278 "Modifications for Crew Training Facilities."
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.	11,900	Facility modifications are included in the FY 1976 C of F project 7278 "Modifications for Crew Training Facilities."

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Space Shuttle	Johnson Space Center Bldg. 30, 72-77-01	Real Time Computer Complex Replacement Computers.	The present 494/360 complex will not accommodate the Space Shuttle data handling requirements	2,340	
Space Shuttle	Johnson Space Center Bldg. 30, 72-77-02	Network Interface Processor/Shuttle Data Processing Complex Interface Equipment	This equipment is required to provide interface for the Network Interface Processor/Shuttle Data Processing Complex.	200	
Space Shuttle	Johnson Space Center Bldg 30, 72-77-03	Digital/Analog Display Devices	Present system maintenance and operating costs are excessive. System components are becoming obsolete.	500	
Space Shuttle	Johnson Space Center Bldg. 30, 72-77-04	Network Interface Processor (NIP) Computer	The computer is required to interface the Orbiter Multi-rate Data Systems through the network to the Mission Control Center.	456	

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Space Shuttle	Johnson Space Center Bldg. 30, 72-77-05	Master Interface Timing Equipment	Present system maintenance and operations cost are excessive. System components are becoming obsolete.	500	
Space Shuttle	Johnson Space Center Bldg. 44, 72-77-06	TDPS Electronics Equipment	This equipment is required to assure compatability between space and ground RF systems, a continuing program of integrated system verification tests must be performed. Success is contingent on the capability of spacecraft and ground RF systems to operate effectively as an integrated unit.	450	

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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.	23,927	
Space Shuttle	Kennedy Space Center Pad A LC-39, 76-76-02	Pad Fuel Cell Servicing System	The existing LC-39 Pad configuration does not include the necessary cryogenic systems to service the Orbiter Fuel Cell System.	533	
Space Shuttle	Kennedy Space Center SRB Processing and Storage, 76-77-01	Transporter, SRB Segments (Forward Section and AFT Booster Assembly)	This requirement is to transport SRB segments from the SRB Processing and Storage Facility to the VAB. No existing equipment at KSC will support this requirement.	700	

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Space Shuttle	Kennedy Space Center Various, 75-77-02	Operational Television System	To provide television surveillance of Space Shuttle processing, such as launch and landing activities, ground tests, safing, and towing operations.	2,374	
Space Shuttle	Kennedy Space Center OPF, 76-77-03	RF Communications and Tracking Checkout System	Provide an end-to-end checkout of the Orbiter S-Band, UHF, Rendezvous Radar, RF Navaids and associated LRU's such as TV via antenna hats over the Orbiter antennas and hardline interface to the IPS equipment.	700	
Space Shuttle	Kennedy Space Center 76-77-04	Wideband Cable Transmission, LCC System	Installation required to automate checkout and switching of wideband circuits in addition to replacing obsolete equipment and installing new equipment in support of the Shuttle program for transmission of LPS data, OTV, OIS-RF, telemetry, weather radar, and DOD data.	1,567	

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Space Shuttle	Kennedy Space Center Launch Control Center 76-77-05	System, Operational Intercom, LCC	System required for prelaunch test and checkout of unique shuttle communications systems.	2,440	
Space Shuttle	Kennedy Space Center 76-77-06	System, Radio Frequency Communications	To provide RF communications for various support agencies (i.e., fire security, medical, maintenance and operations). The existing system will be modified and expanded as required to support test and emergency response requirements.	1,720	
Space Shuttle	Kennedy Space Center 76-77-07	Pad Hypergolic Servicing System	The existing LC-39 Pad configuration does not include the necessary hypergolic fuel system required to service the Shuttle vehicles.	1,808	

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Space Shuttle	Kennedy Space Center HMF, 76-77-08	System, FRCS/PBK Processing Fluids M7-1212	The capability to process the FRCS and PBK modules at the Hypergol Maintenance Facility (HMF) does not exist. These are new systems which must be installed to support the Shuttle off line module processing. No existing equipment is available to satisfy this requirement.	1,108	
Space Shuttle	Kennedy Space Center Hypergol Maint. & C/O 76-77-09	System, APS Processing Fluids, M7-961	The capability to process the L-APS and R-APS modules at the Hypergol Maintenance Facility (HMF) does not exist. These are new systems which must be installed to support the Shuttle off-line module processing. No existing equipment is available to satisfy this requirement.	1,850	

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Space Shuttle	Kennedy Space Center MLP, 76-77-10	Platform, Servicing and Access, SSME	Access to the Orbiter SSME is required in the A&I bays for checkout operations and contingency access is required at the pad in the event of engine problems on the pad.	286	
Space Shuttle	Kennedy Space Center MLP, 76-77-11	Fuel, Umbilical Plate	To provide a servicing and separation interface of ground-to-Orbiter launch umbilicals, and to reduce umbilical installation time lines.	1,587	
Space Shuttle	Kennedy Space Center OPF, 76-77-12	Equipment Access Set - Mid-Fuselage Horizontal	To provide access to the equipment bays of the mid-fuselages, horizontal Orbiters.	1,403	
Space Shuttle	Kennedy Space Center MLP, 76-77-13	Oxidizer, Umbilical Plate	To provide a servicing and separation interface of ground-to-Orbiter launch umbilicals, and to reduce umbilical installation time lines.	5,369	

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Space Shuttle	Kennedy Space Center Launch Pads, 76-77-14	Plate, ECLSS Forward Umbilical	To limit GSE induced line loads reacted at the Orbiter coupling halves and to effectively reduce Orbiter pre-launch time-lines.	1,450	
Space Shuttle	Kennedy Space Center Operations and Checkout Building, 76-77-15	Canister Vertical/ Horizontal	Canister will house all configurations of payloads during transfer from the various payload processing facilities to the orbiter and return. The canister must be configured especially for Shuttle payloads, therefore no existing equipment is available to satisfy this requirement.	1,400	

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Space Shuttle	Kennedy Space Center Operations and Checkout Building, 76-77-16	Canister Transporter	Transporter will be used to transport the payload container from the payload processing facilities to the pad and return. The transporter is required to transport the Shuttle - peculiar payload canister.	300	
Space Shuttle	Marshall Space Flight Center, 62-77-01	Hydrodynamic Support for MVGVT Program	This equipment is required to support the Ground Vibration test article in the launch configuration.	572	
Space Shuttle	Michoud Assembly Facility 63-77-01	Test, Production, Transportation and Material Handling Equipment	This equipment is required to test, produce, and transport material and components during manufacture of the External Tank.	1,052	
Space Shuttle	National Space Technology Laboratories, 64-77-01	Space Shuttle Main Engine Ground Support Equipment	This equipment is required at NSTL to support handling and checkout of SSME Engines during Space Shuttle MPTA Test Program	1,500	

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Space Shuttle	Flight Research Center Secondary Landing Site 24-77-01	Systems, Portable Fluid Distribution	To distribute fluids and gases from GSE to GSE and from GSE to Orbiter interfaces at sites not equipped with a fixed fluid distribution system. Filtration shall be provided in the Orbiter ground servicing lines as close to the vehicle interface as possible. Line sizes and configuration shall be compatible with the fluid media, flow, pressure and temperature requirements.	278	
Space Flight Operations	Johnson Space Center Spacecraft Systems Lab Bldg. 16, 72-77-07	Engineering Simulations Computer System	The Engineering studies which this equipment will support will provide technical insight in the design and development of specific guidance and control systems and in the interaction of overall guidance and control systems.	2,060	

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Space Applications	Johnson Space Center Bldg. 17, 72-77-08	Earth Resources Interactive Data System (ERIDS)	Integrated data system to provide versatile data processing to earth resources application projects during 1978-1983 time frame.	776	Facilities modifications will be included in the FY 1978 budget submission.
Space Flight Operations Payloads	Ames Research Center 21-77-10	Spacelab Airborne Simulation System	To provide a low, cost streamlined method for management of experimental payloads for Spacelab which can be studied and developed to aid Spacelab planning by means of a high-fidelity simulator that can be flown in aircraft on automatic scientific missions.	1,500	

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Aeronautical Research and Technology	Ames Research Center Bldg. 210, 243, 239, 21-77-01	Simulation Control System (Olympus) to replace EAI 8400 Simulation Computers	To provide a system of interconnected computers for control and computation required for Ames simulators.	1,500	
Aeronautical Research and Technology	Ames Research Center Bldg. N226, 21-77-02	Data Acquisition System	To provide real-time monitoring and display of tunnel conditions and aerodynamic parameters and data acquisition.	408	
Aeronautical Research and Technology	Ames Research Center Bldg. 243, 21-77-03	Analog/Digital (Hybrid) Controller	To provide controller for driving hydraulic powered pilot control columns located in motion simulators.	310	
Aeronautical Research and Technology	Ames Research Center Bldg. 243, 21-77-04	Cathode Ray Tube Graphics System	To provide surface shading and contouring graphics for future simulations of V/STOL aircraft.	600	

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Aeronautical Research and Technology	Ames Research Center Bldg N227, 21-77-05	Vehicle Separation System	To provide the capability of measuring the separation aerodynamics of two large models.	400	
Aeronautical Research and Technology	Ames Research Center Bldg. N233, 21-77-06	Computer Output Microfilm (COM) Recorder	To provide replacement COM equipment which has editing and data manipulating capability for production of technical and administrative reports.	400	
Space Research and Technology	Ames Research Center Bldg. 243, 21-77-07	Motion Control System	To provide replacement motion generator servo control amplifiers, ancillary control, and performance monitoring equipment for stability of motion performance in motion simulator.	400	

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Space Research and Technology	Ames Research Center Bldg. 233, 21-77-08	High Performance Disk System for CYBER 76	To provide overall computer performance and disk expansion to support computational fluid dynamics, short haul aircraft technology, atmospheric modeling, and computer aided aircraft design.	510	
Space Research and Technology	Ames Research Center 21-77-09	Large Capacity Storage System for Control Computer Facility	To provide online, low cost, large data and program storage capability to improve system performance and job turnaround.	300	
Tracking and Data Acquisition	Goddard Space Flight Center, Data Interpretation Lab. Bldg. 23, 51-77-01	Image Processing Sub-System. Completion of Medium Size Computer Sub-System to process data digitally. Includes wideband recorders to generate the high precision output products required by experimenters.	Required for approved imaging satellites, including NIMBUS-G, for high accuracy high resolution image processing.	300	

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Tracking and Data Acquisition	Goddard Space Flight Center Data Interpretation Lab. Bldg. 23 51-77-02	TELOPS Sub-System. High Speed, high capacity random access disc storage.	Required to handle transfer of large files of data between the TELOPS and existing 1108 computers.	300	
Tracking and Data Acquisition	Goddard Space Flight Center Data Interpretation Lab. Bldg. 23 51-77-03	Wideband Communications Interface System. Computing system to perform preprocessing function on incoming data.	Required to match incoming data characteristics with the present capability of the information processing installation.	300	

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Tracking and Data Acquisition	Goddard Space Flight Center, Space Operations Facility, Bldg. 14, 51-77-04	SEASAT Control Center System. Modification of consoles and display systems to meet requirements of the experiments carried by SEASATS and new data handling equipment to accommodate wideband signals from the Synthetic Aperture Radar.	Required to modify existing AE/OSO Control Center to conduct unique real-time operations of SEASAT.	300	
Tracking and Data Acquisition	Goddard Space Flight Center, Space Operations Facility, Bldg. 14 51-77-05	Computer Replacement MSOCC #1. Replacement computer systems for obsolescent XDS 930 computers.	Required to process real-time telemetry, drive displays, and format command messages for the many and varied spacecraft support by MSOCC #1.	1,700	
Tracking and Data Acquisition	Goddard Space Flight Center, Space Operations Facility, Bldg. 14 51-77-06	MDHS Augmentation. New communication interface equipment to accommodate digital data transmission from network stations, and data handling equipment for higher data rates.	Modification to existing command and control consoles of the MDHS required to conduct the real-time operations of the NIMBUS-G mission.	600	

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Tracking and Data Acquisition	Goddard Space Flight Center, Space Operations Facility, Bldg. 14 51-77-07	NASCOM Data Storage and Playback Sub-System. Wideband tape recorders and disc storage equipment used to buffer data.	Required for "Rent-Pipe" wideband systems that depend on reliable communication systems and which protect against data loss from equipment failures.	700	
Tracking and Data Acquisition	Goddard Space Flight Center, Space Operations Facility Bldg. 14 51-77-08	NASCOM Wideband Interface Subsystem. Block demultiplexing equipment interfacing with time division multiplexing systems used for compatible transmission systems data rates.	Required to allow reconfiguration of wideband channels to meet project data requirements where different transmission rates are most cost effective.	500	
Tracking and Data Acquisition	Jet Propulsion Laboratory Combined Electronics Bldg., Bldg. 125, 55-77-01	Wideband Data Handling System. Wideband digital and analog tape recorders, signal conditioner and cross correlator. Provides developmental data handling system which will be used in the Deep Space Network to recover and process special telemetry and tracking data.	Provides increased ground tracking precision required for entry probe (Pioneer Venus) and outer planet (Mariner Jupiter Saturn) type missions.	350	

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Tracking and Data Acquisition	Jet Propulsion Laboratory Network Operations Control Center, Bldg. 202, 55-77-02	NASCOM Digital Data Retrieval System. Mini-computers and associated equipment for error detection, correction, and for real-time data recall from DSN stations.	Required to interface with the communications monitor/formatters at the DSN stations to ensure corrected data is provided to the control and data computation centers.	500	

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