FG

National Aeronautics and Space Administration

FG

BUDGET ESTIMATES

FISCAL YEAR **1977**

Volume I

AGENCY SUMMARY

RESEARCH AND DEVELOPMENT

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1977 ESTIMATES

AGENCY SUMMARY AND RESEARCH AND DEVELOPMENT

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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

National Aeronautics and Space Administration

SPACE FLIGHT

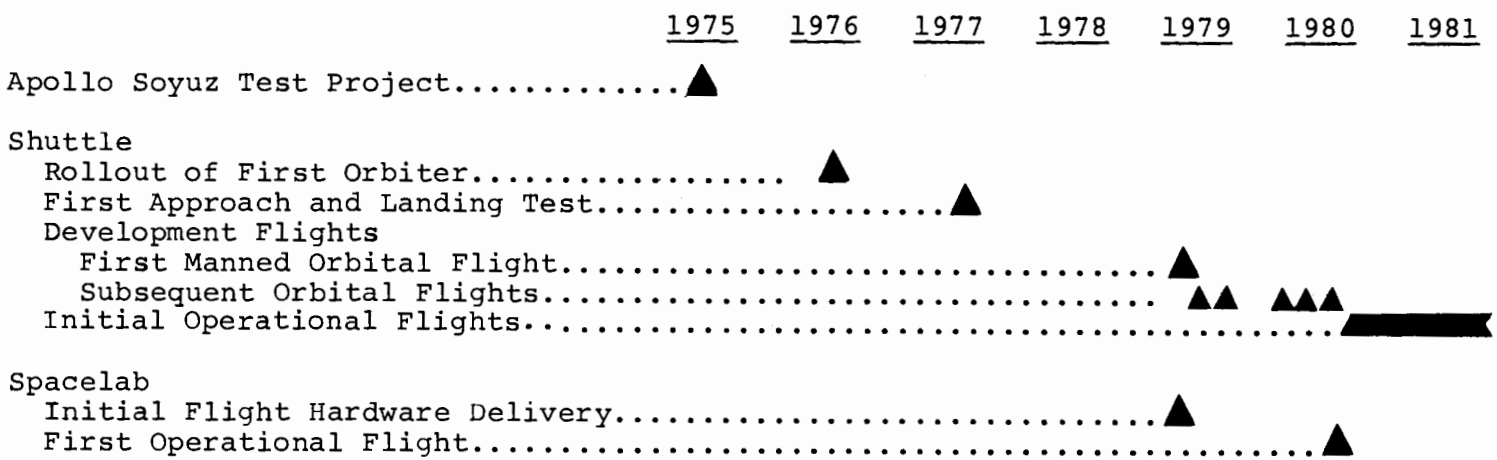
- Promote International Cooperation in Space

  --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

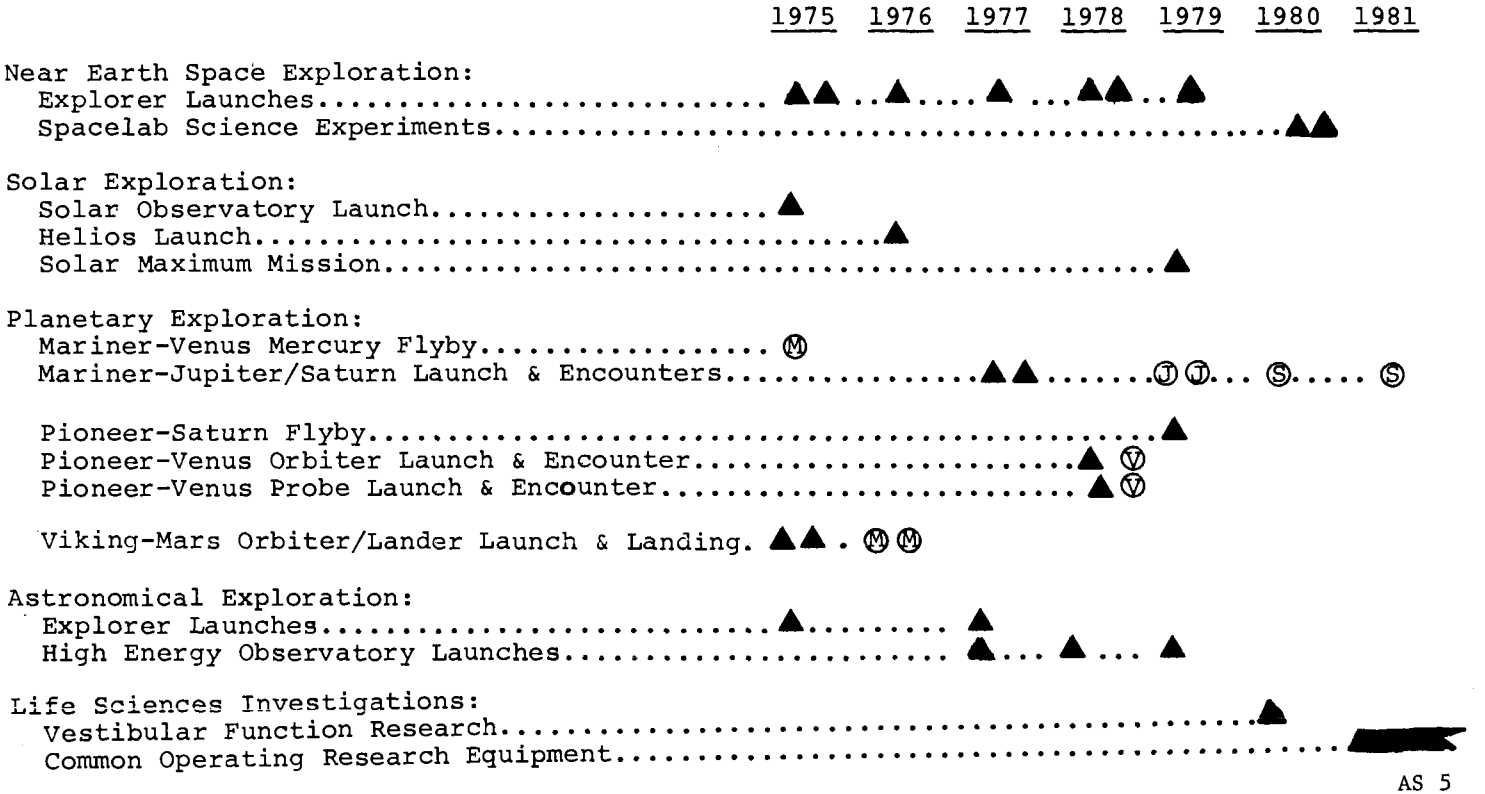


National Aeronautics and Space Administration

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



National Aeronautics and Space Administration

SPACE APPLICATIONS

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

MAJOR FLIGHT ACTIVITY

	1975	1976	1977	1978	1979	1980	1981
Earth Resources Detection and Monitoring:							
LANDSATS-2 & C	▲		▲				
Heat Capacity Mapping Mission				▲			
Earth Dynamics Monitoring and Forecasting:							
LAGEOS		▲					
Magnetic Field Satellite						▲	
Ocean Condition Monitoring and Forecasting:							
GEOS-3	▲						
SEASAT-A				▲			
Environmental Quality Monitoring							
NIMBUS-G				▲			
Stratospheric Aerosol and Gas Experiment					▲		
Weather & Climate Observation & Forecasting:							
NIMBUS-6	▲						
Synchronous Meteorological Satellite-2	▲						
TIROS-N				▲			
Space Communications:							
CAS-C		▲					

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

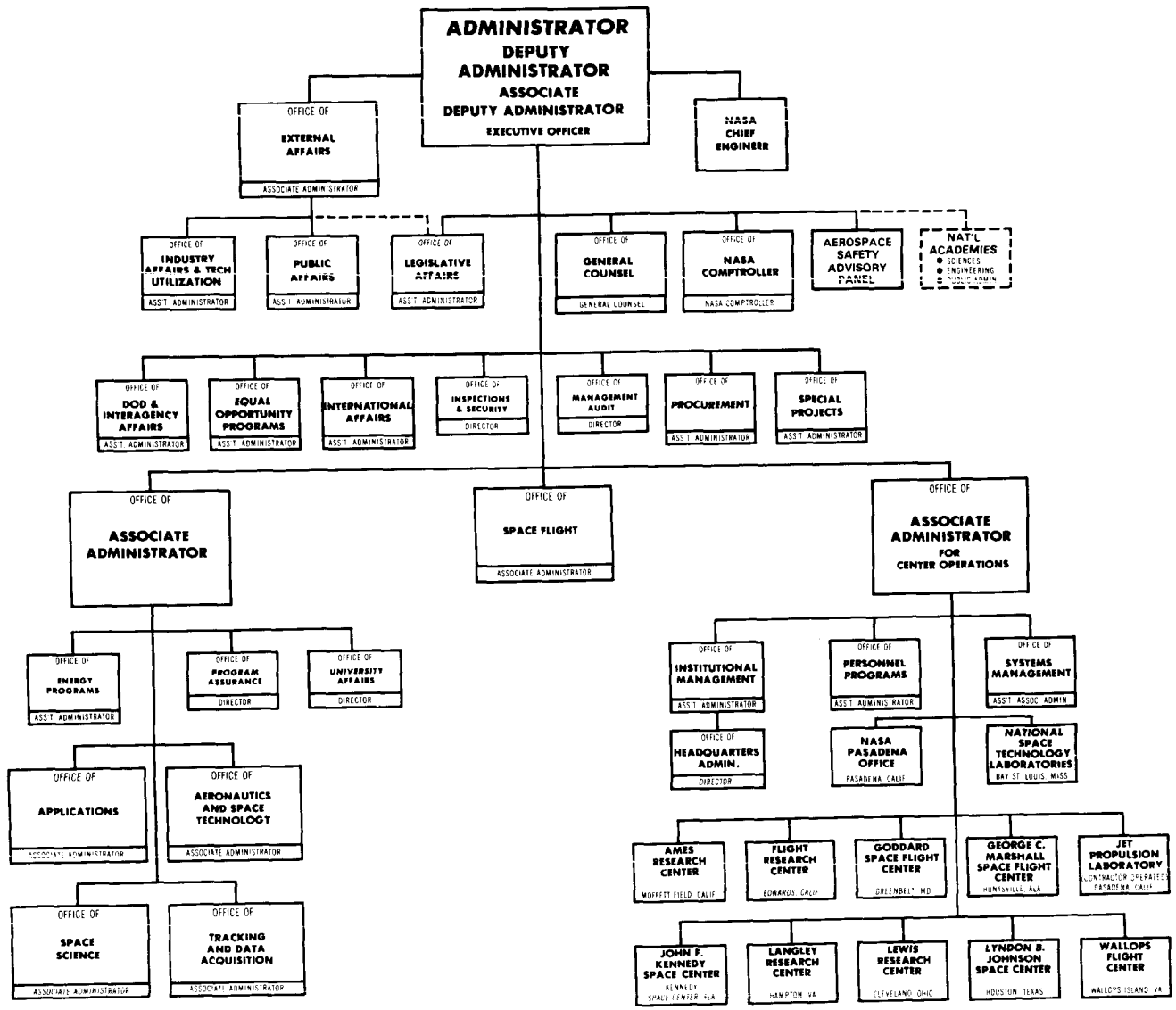
RESEARCH AND PROGRAM MANAGEMENT

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



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.

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	200,800
(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	83,926	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	2,680,334	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

RESEARCH AND DEVELOPMENT—Continued

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	----------	----------	----------	----------	332	----------	----------	----------
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

	1975 actual	1976 estimate	TQ estimate	1977 estimate
Note.—Reconciliation of budget plan to obligations:				
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	---	11,315	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	151,898	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	52,088	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	---	13,954	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
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	54,620	116,253	16,164	193,992	130,659	105,849
	1976	2,677,380	1,000,194	110,045	415,040	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

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 Vehciles	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	STS 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 Monitoring	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	.5	3.7	.7	2.5	---	---	---	---
Other projects.....	45.4	45.4	---	---	---	---	---	---	---	---
Earth and ocean physics.....	18.9	---	7.7	11.2	---	---	---	---	---	---
Space processing.....	3.3	---	---	---	---	---	3.3	---	---	---
Communications.....	11.0	---	---	---	---	---	---	11.0	---	---
Data management.....	4.0	---	---	---	---	1.0	---	---	3.0	---
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

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:

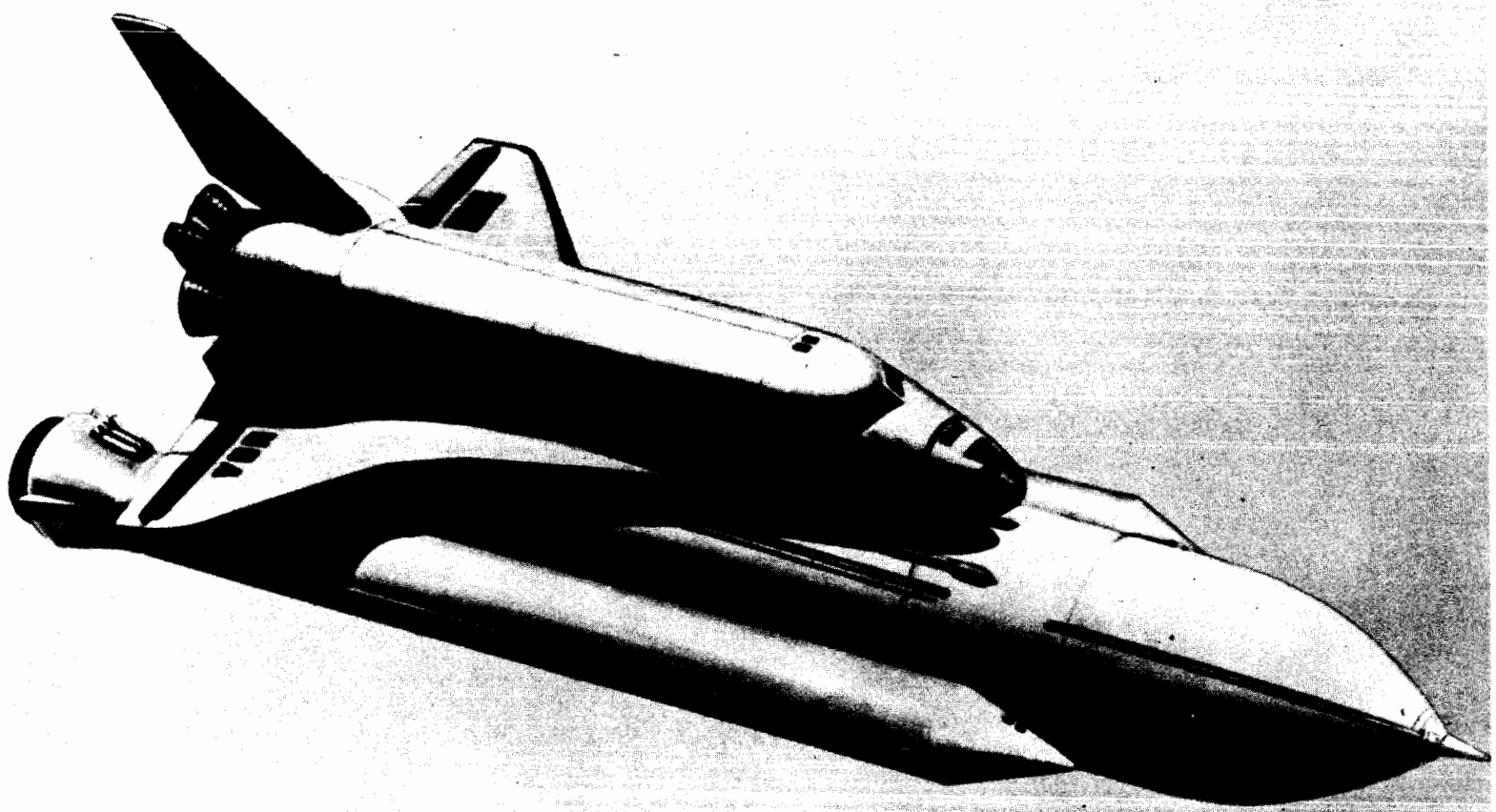
The Space Shuttle is the key element of an economical space transportation system that will provide a wide variety of national and international users with round-trip access to space beginning in the 1980's. The Shuttle will be the first reusable space vehicle and will be configured to carry many different 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,

SPACE SHUTTLE SYSTEM



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	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	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 of 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

ORBITER NO. 1 ASSEMBLY
AT PALMDALE
WINGS-TAIL-AFT, MID,
AND FWD. FUSELAGE
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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

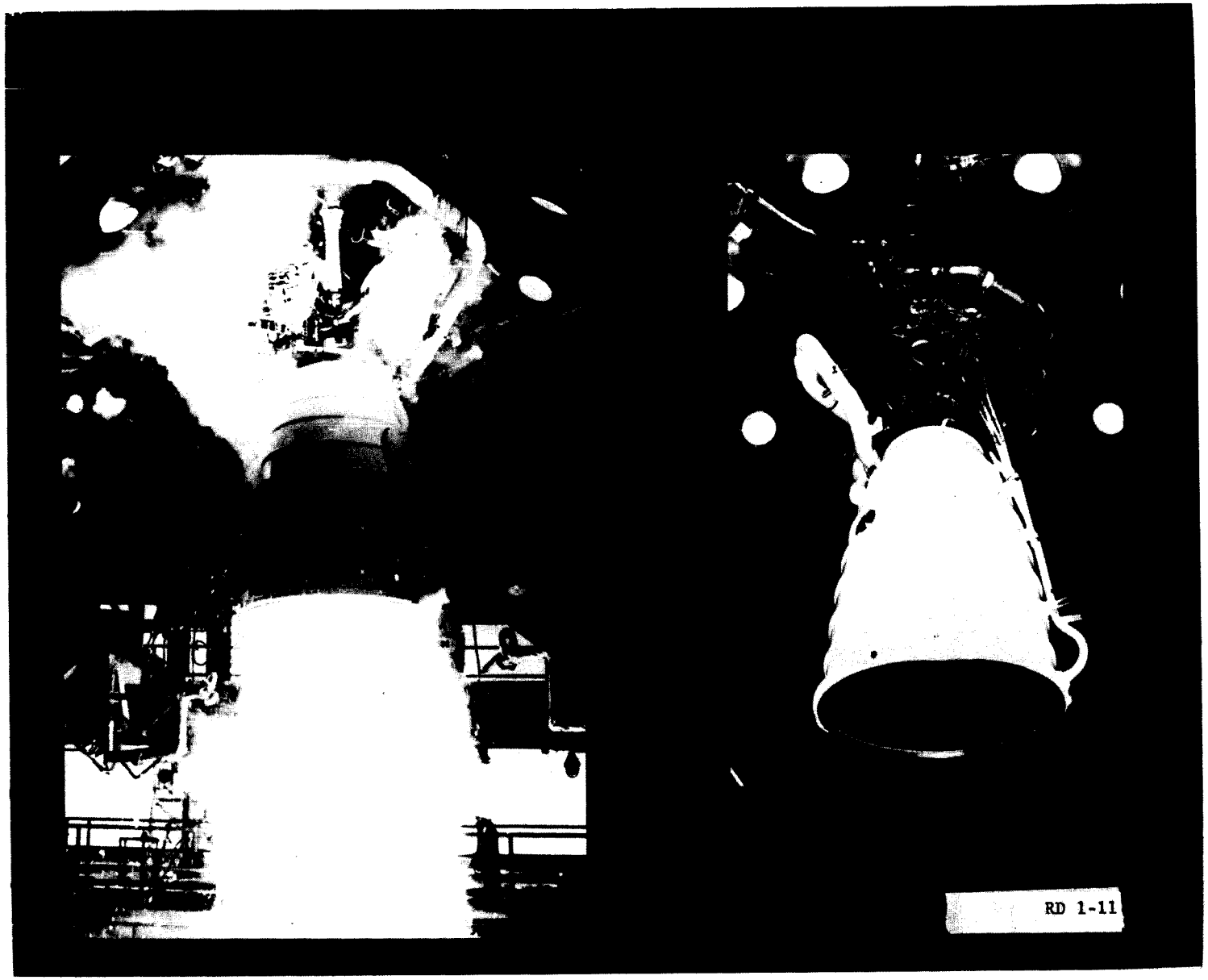
	1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget Estimate
			(Thousands of Dollars)			
Main engine.....	95,300	135,500	135,500	36,000	36,000	193,800

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.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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/1g 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.

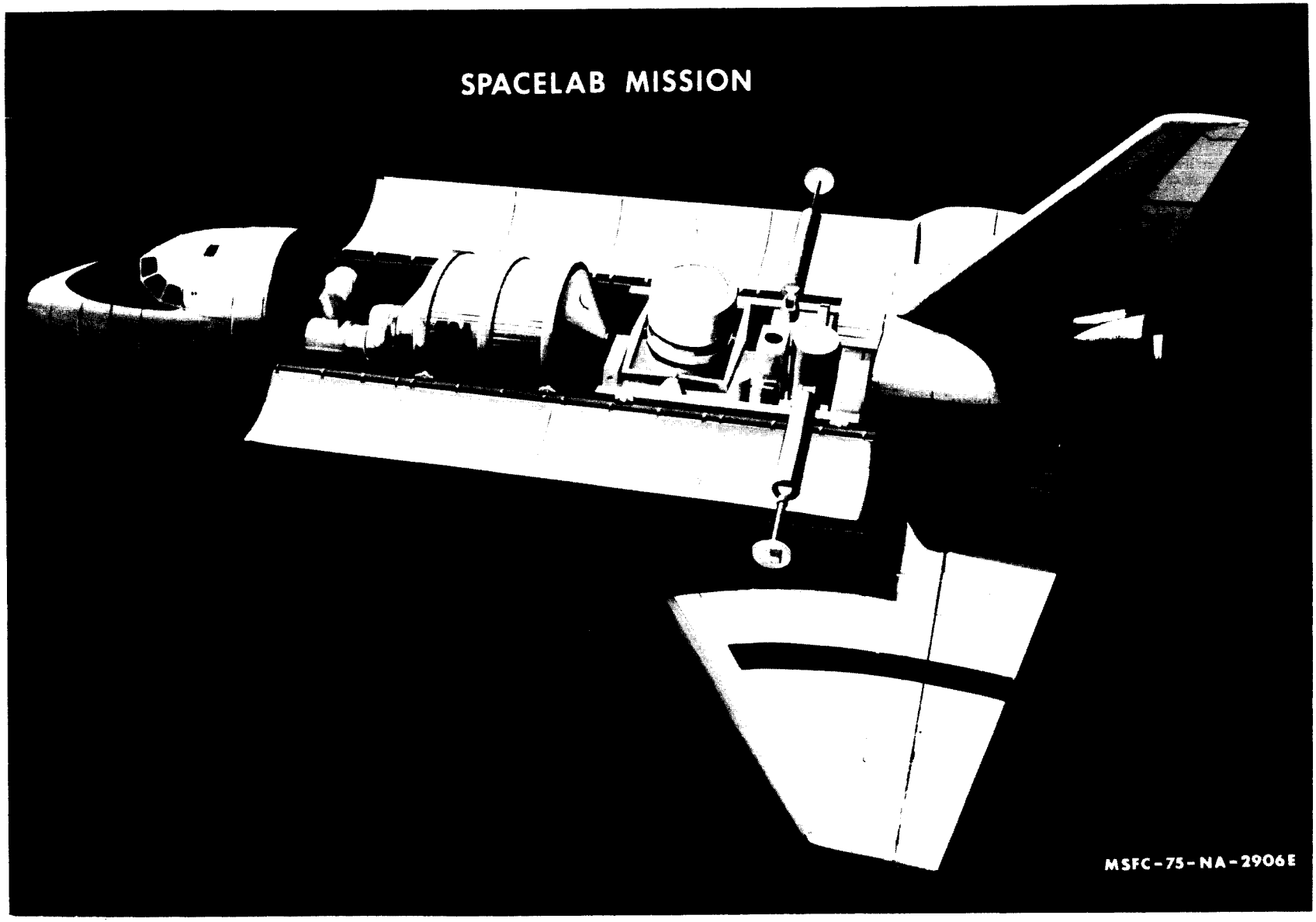
Spacelab

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	1977 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


SPACELAB MISSION
MSFC-75-NA-2906E

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/1g 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 1g crew trainer at the Johnson Space Center, thus eliminating the requirement to procure a separate 1g 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/1g 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)			
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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

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	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

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	1977 Budget Estimate
	(Thousands of Dollars)				
41,100	40,000	45,200	10,400	11,900	45,900

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.

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	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	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

	1976		Transition Quarter		1977
1975 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

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1977 ESTIMATES

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	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	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:

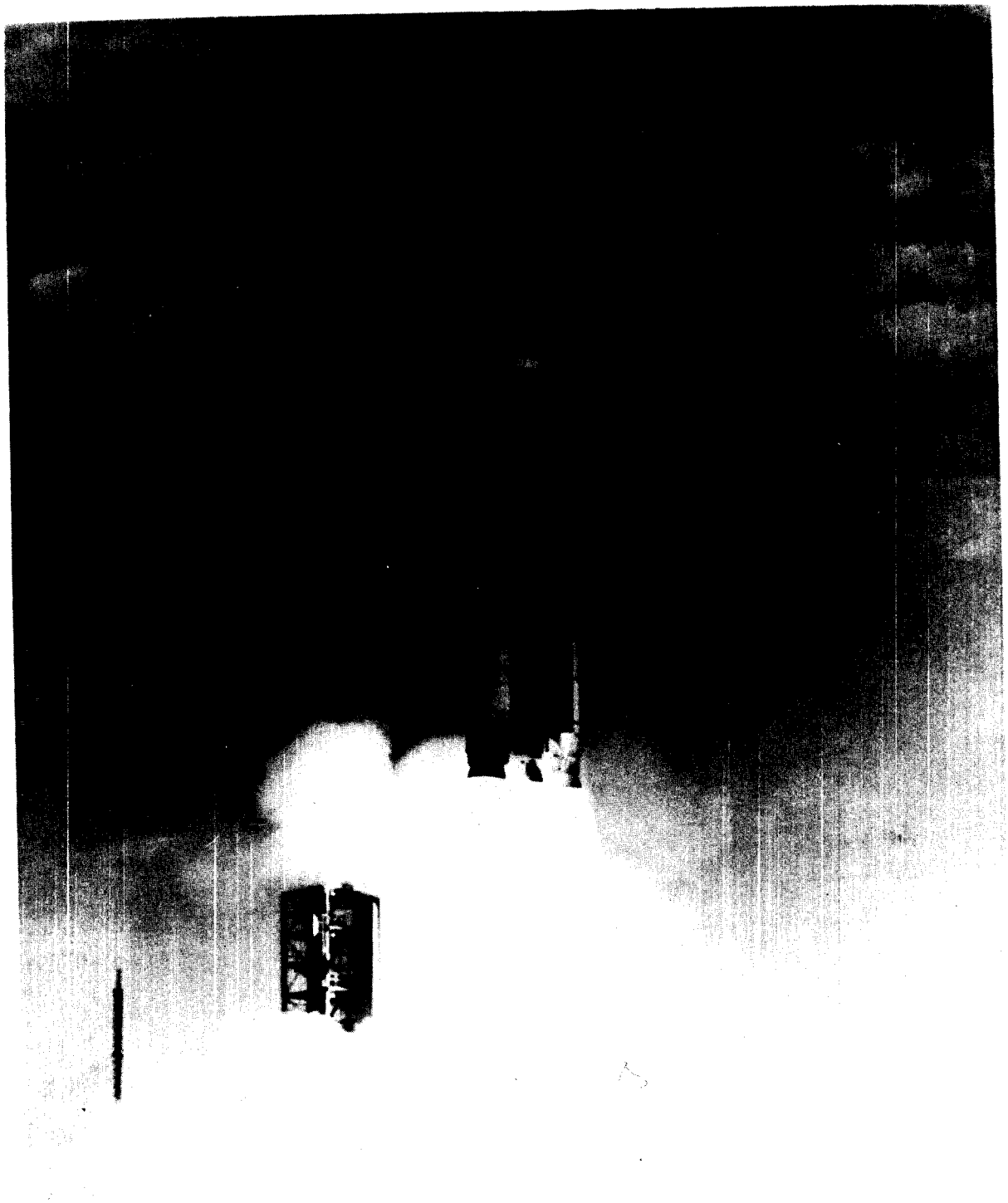
The Centaur program provides for the procurement and launch of two booster stages, the Atlas and Titan, and an upper stage, the Centaur. Centaur is a high performance upper stage, the most powerful used by NASA for automated missions. It is being used with the Atlas booster for high energy missions, 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.



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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	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	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.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1977 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE SCIENCE PROGRAMS

	Budget Plan					
		1976		Transition Quarter		1977
Programs	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

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	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	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

	1976		Transition Quarter		1977
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	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.

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	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	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	1,300	5,000

OBJECTIVES AND STATUS:

The purpose of this effort is to obtain the maximum return on the investment represented by the data gathered in the Space Science program, including that from a number of spacecraft which are operating well beyond their planned lifetimes.

Limited operation of spacecraft, beyond the times originally planned, has made additional data available for specific investigations, with preference being given to correlative operations designed to illuminate physical problems, and to the exploitation of unusual opportunities such as unexpected encounters with comets.

Further work using existing data is also supported, with emphasis on correlative studies. Under this project, investigators are expected to prepare data, complete with calibrations, in a form suitable for deposit in the National Space Science Data Center (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 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 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

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

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	1977 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 for 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 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 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

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	1977 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 retro-reflectors 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		1977
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	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;

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)

	1976		Transition Quarter		1977
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	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)

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	1977 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

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	1977 Budget 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

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	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
Global Atmospheric Research Program	Data Systems Test	1976
	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 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 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 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)	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	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	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	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	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 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	2,500	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

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.

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 GHz. 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 experimenter 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

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	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 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 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

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

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

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.

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

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	1977 Budget 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

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	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

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	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		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	1977 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.

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		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	1977 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 workload 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

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 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

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	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		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	1977 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 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 Budget 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		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	1977 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

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		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	1977 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		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	1977 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	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	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

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	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

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter 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.

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		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	1977 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

	1976		Transition Quarter		1977
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	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	1976		Transition Quarter		1977
	Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	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.

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:

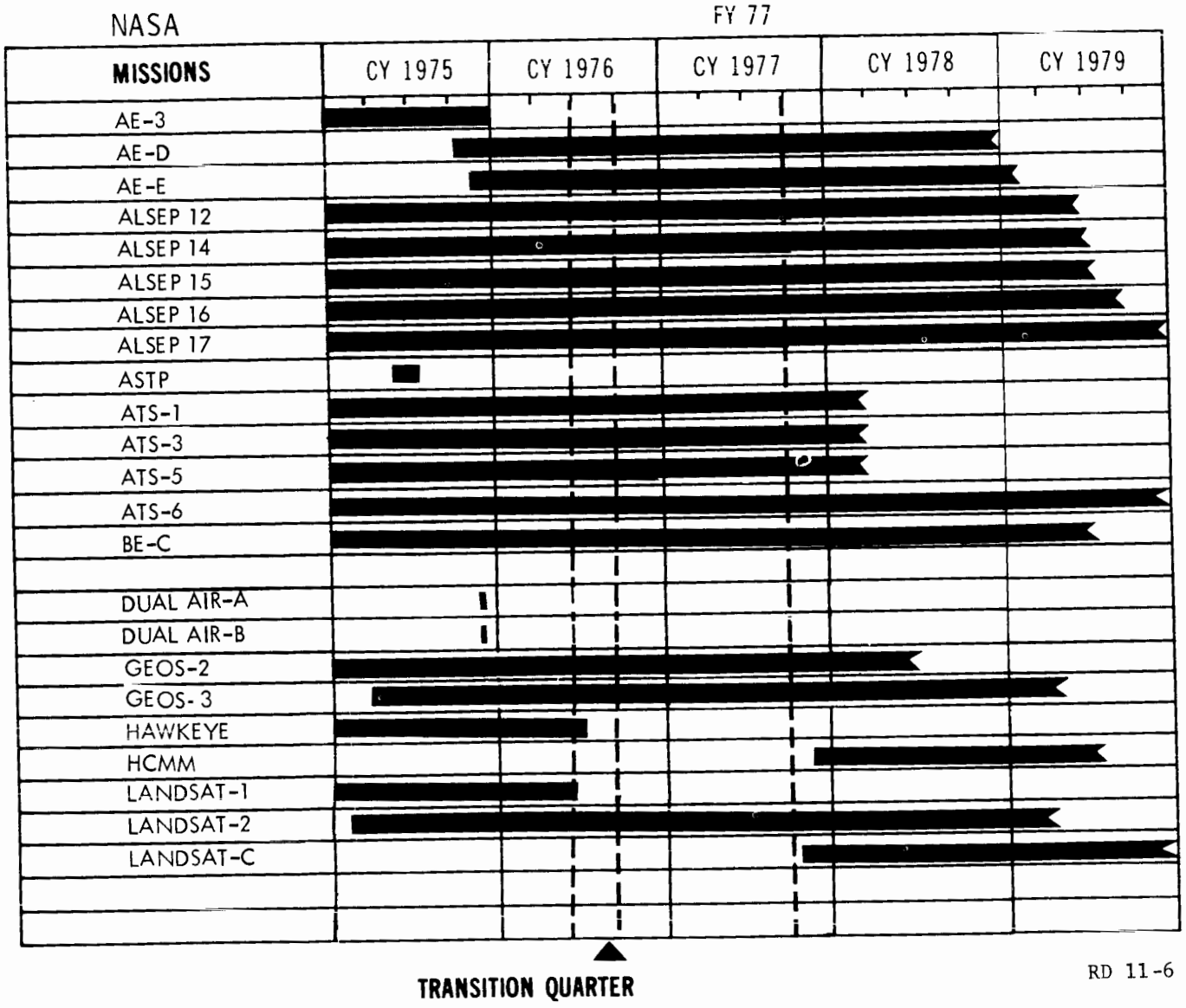
The FY 1977 funding requirements for the Spaceflight Tracking and Data Network operations provide for the maintenance and operation of the network facilities, as well as the related logistics, network support, and computer programming costs associated with the around-the-clock operation of the network. 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		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	1977 Budget Estimate
		(Thousands of Dollars)			
37,489	38,400	40,500	10,200	10,400	43,000

SPACEFLIGHT TRACKING AND DATA NETWORK WORKLOAD

NASA



RD 11-6

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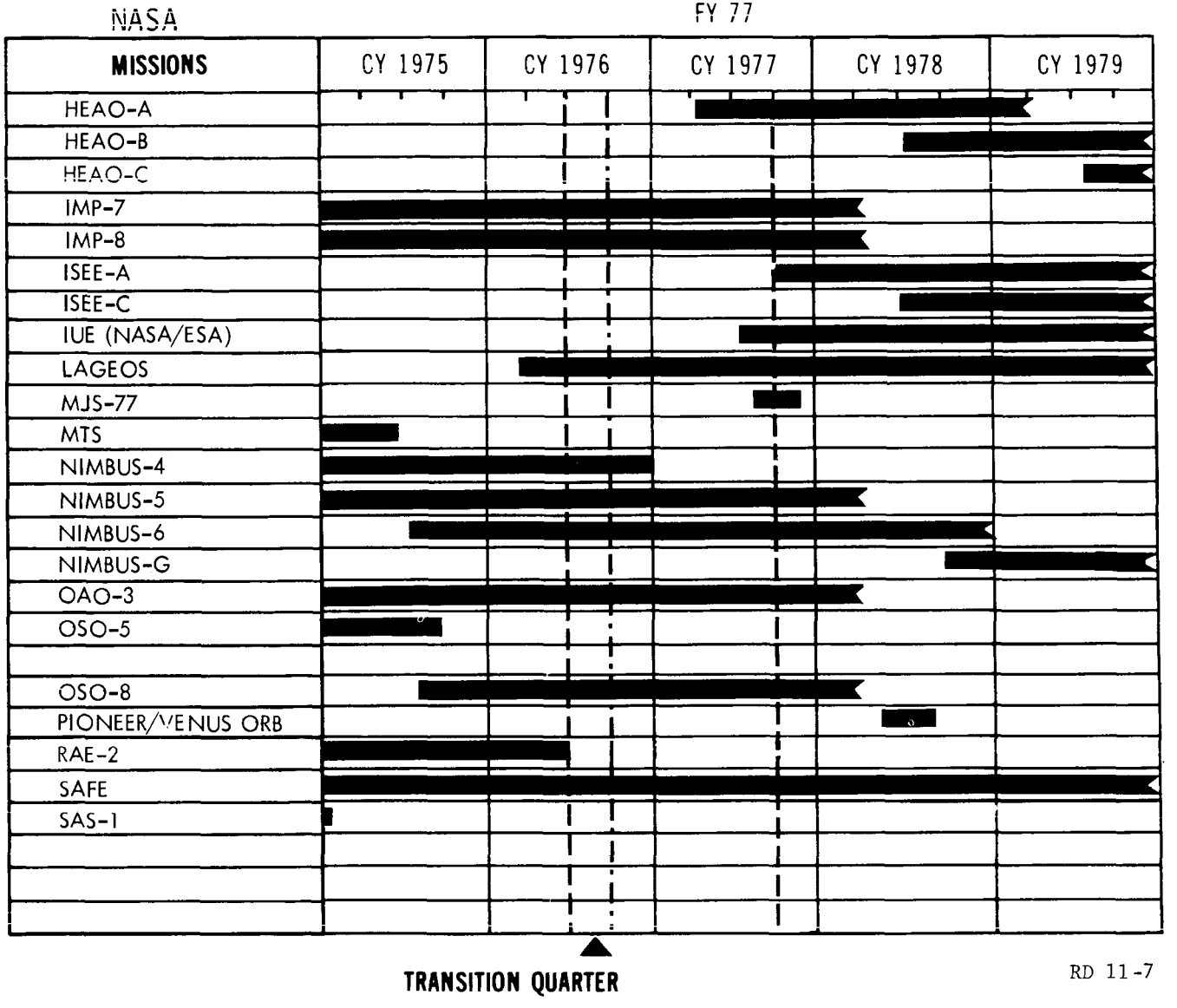

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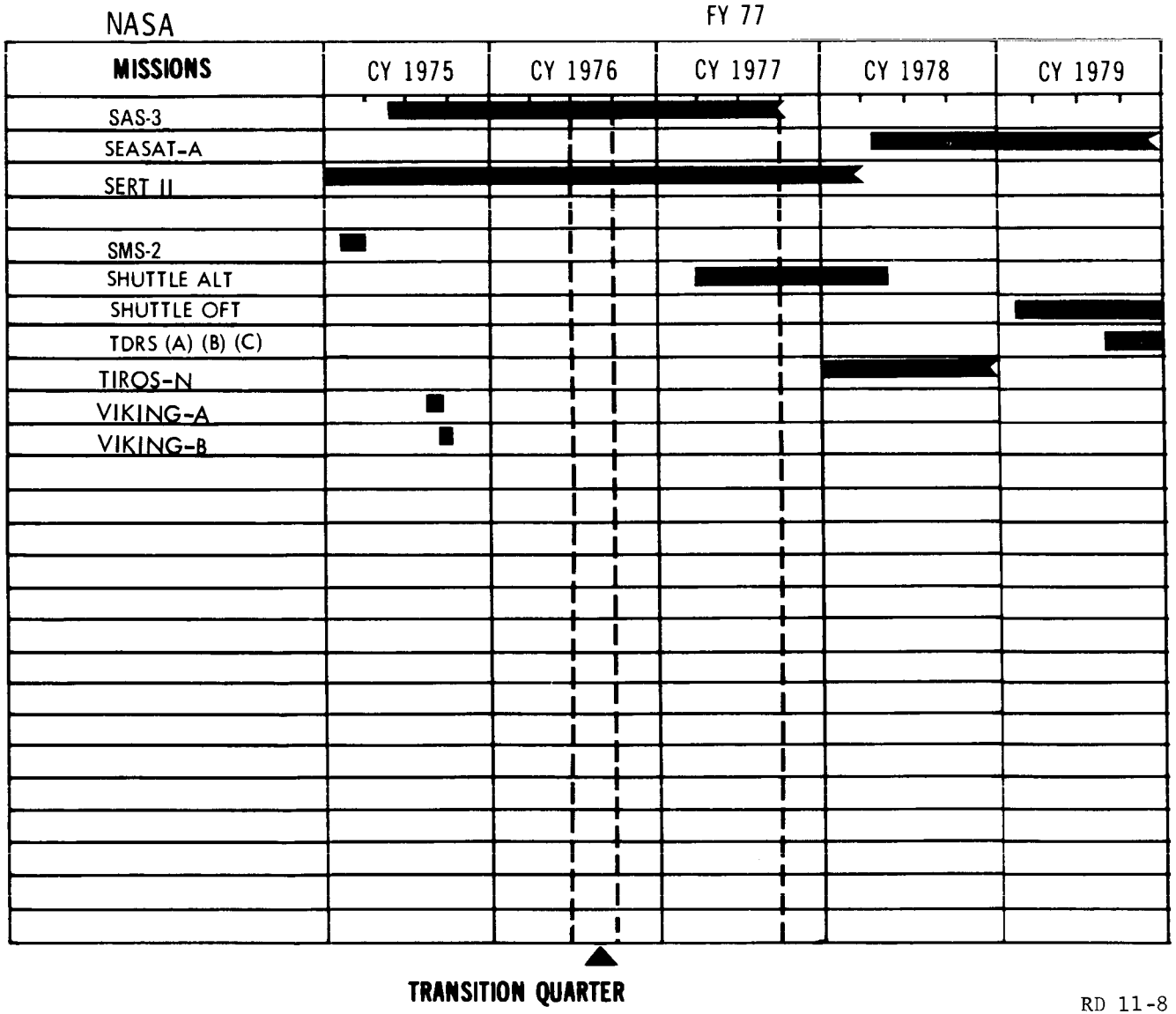
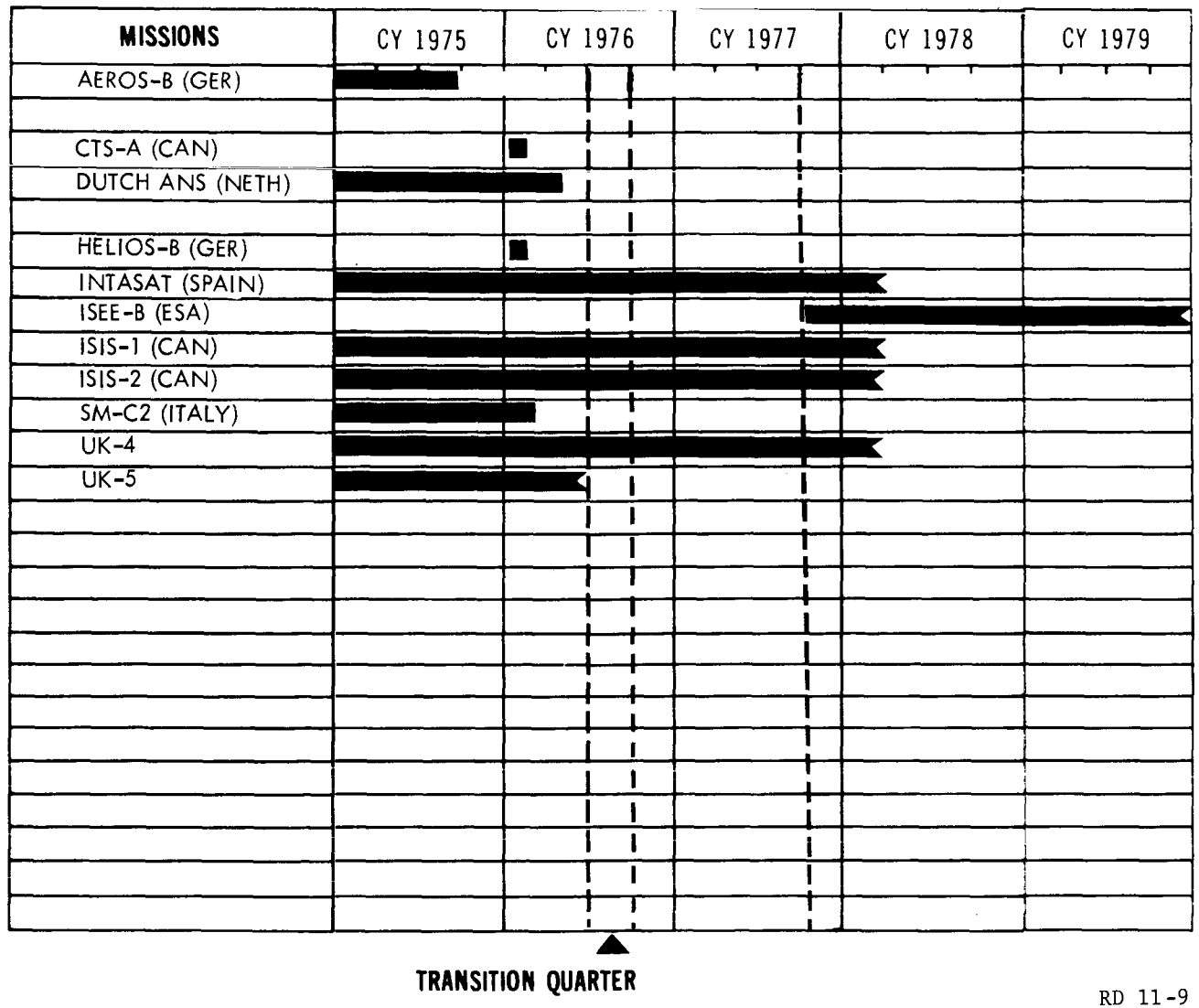


SPACEFLIGHT TRACKING AND DATA NETWORK WORKLOAD

COOPERATIVE INTERNATIONAL

FY 77



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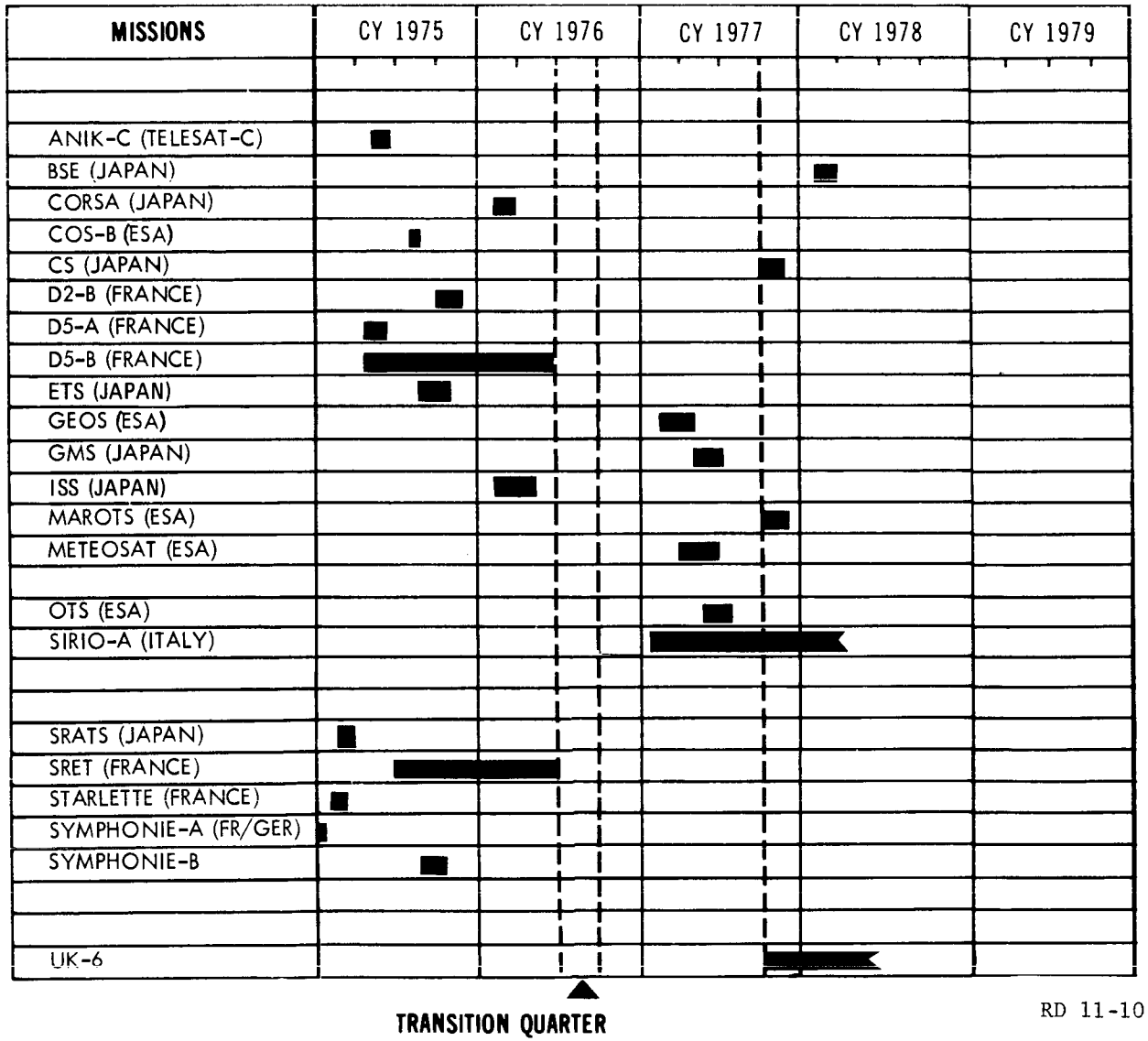
INTERNATIONAL

FY 77



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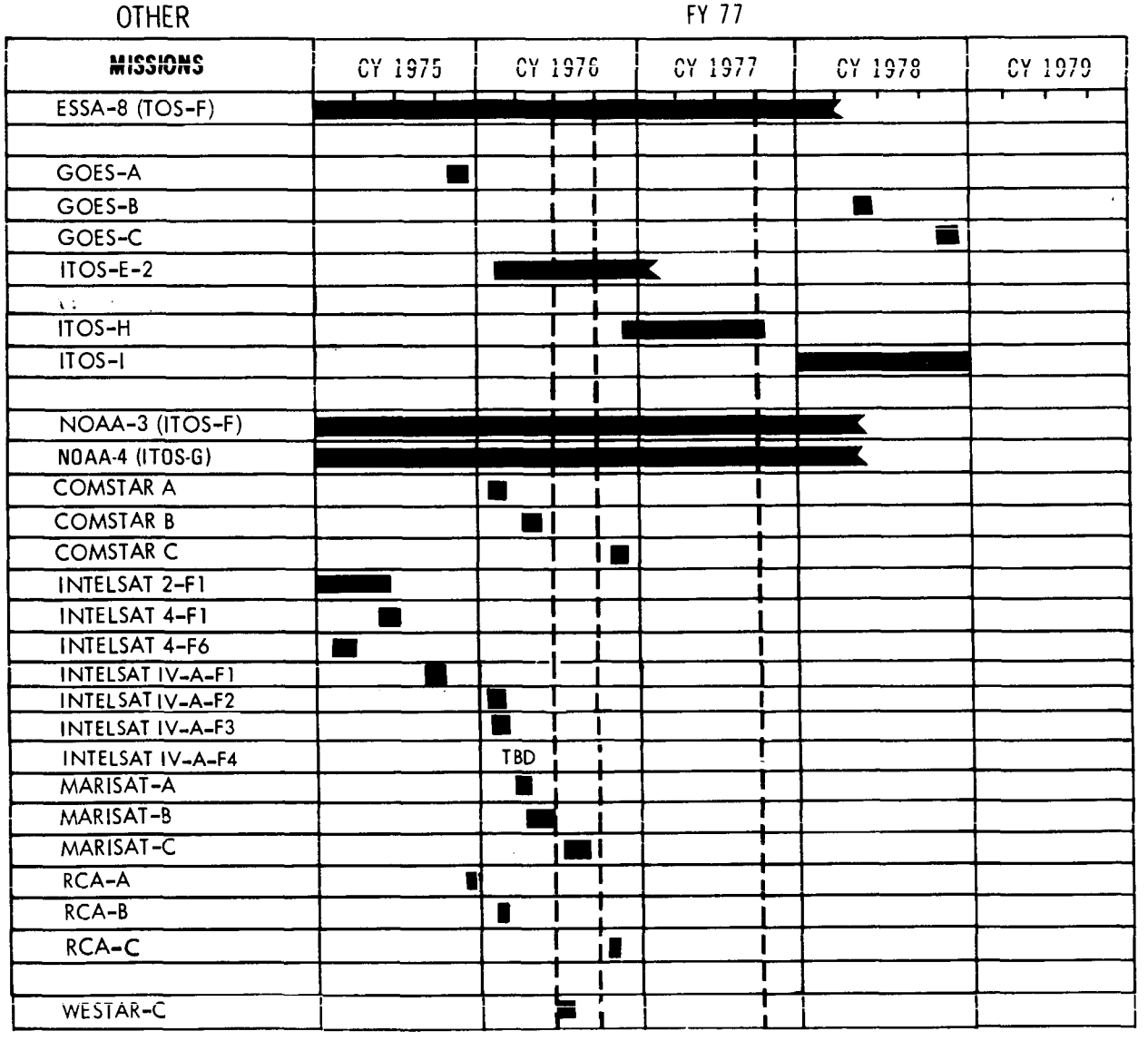

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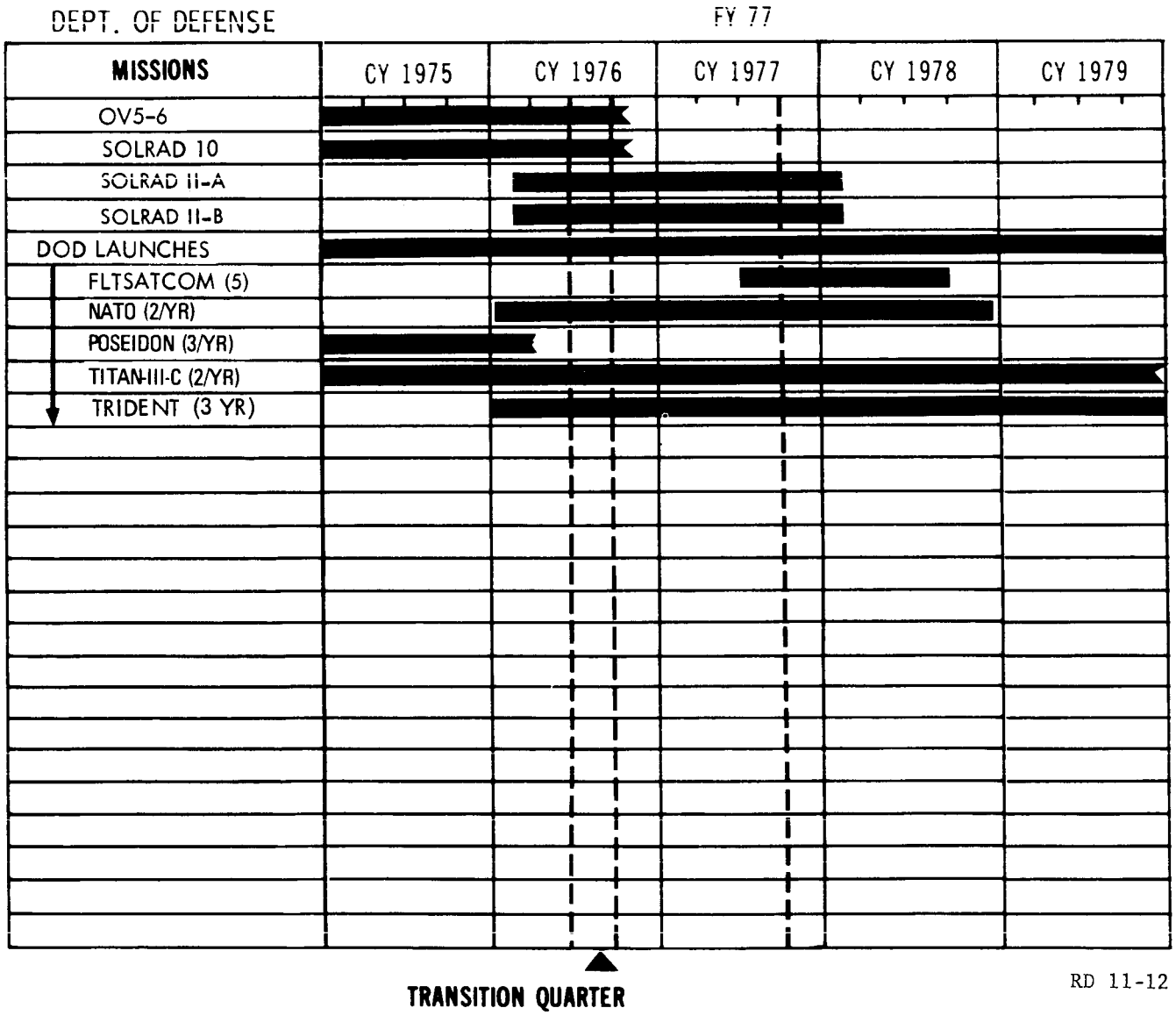


RD 11-12

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.

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.

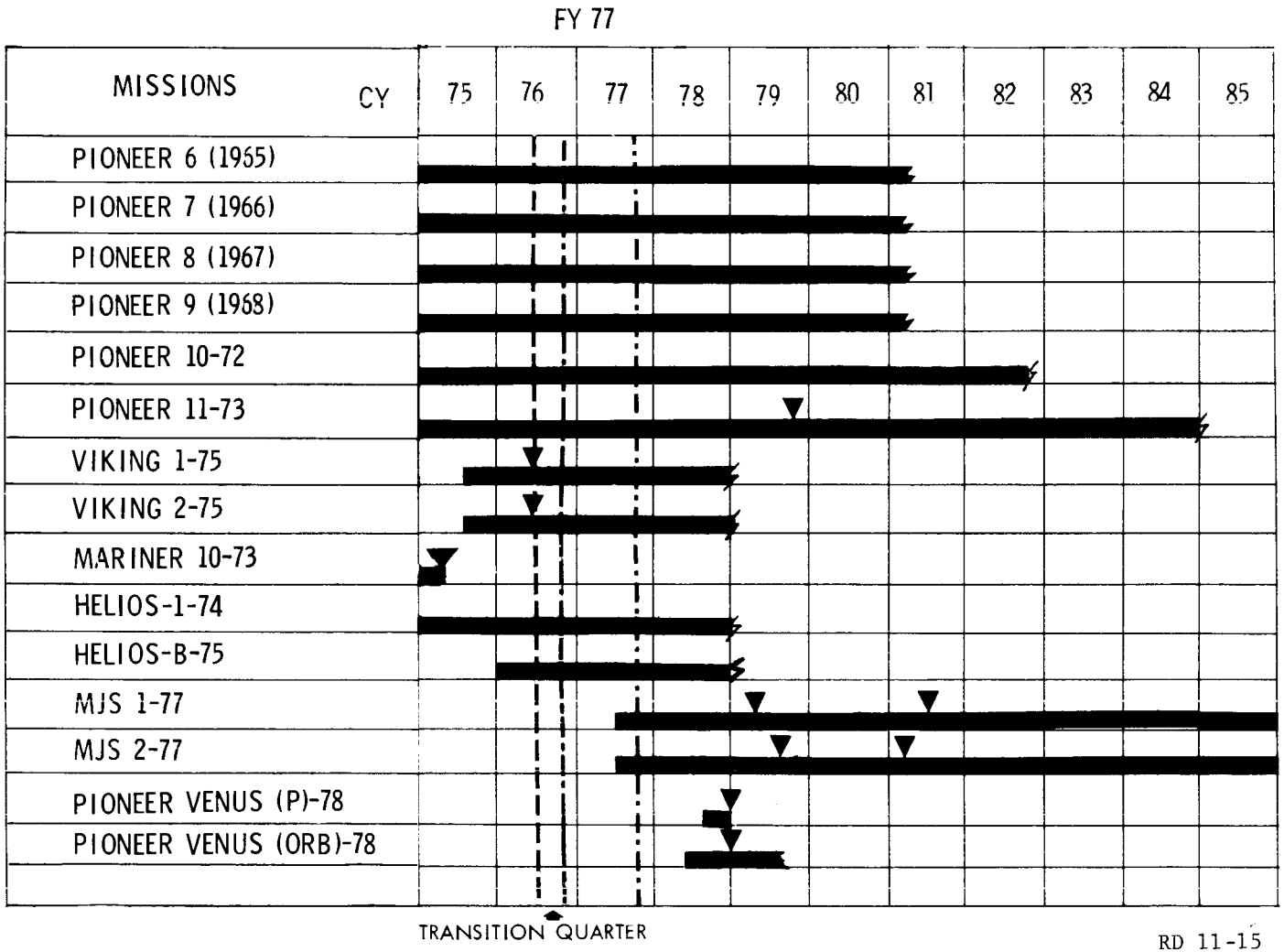
Aeronautics and Sounding Rocket Support

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



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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

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	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.

		1976		Transition Quarter		1977
	1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	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		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	Current Estimate	1977 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

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	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

1975 Actual	1976 Budget Estimate	1976 Current Estimate	Transition Quarter Budget Estimate	Transition Quarter Current Estimate	1977 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

	1976		Transition Quarter		
1975 Actual	Budget Estimate	Current Estimate	Budget Estimate	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.

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

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.